FM 5-34

DEPARTMENT OF THE ARMY FIELD MANUAL

ENGINEER FIELD DATA

HEADQUARTERS, DEPARTMENT OF THE ARMY

JUNE 1962

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CHAPTER 1

INTRODUCTION

Section I. Purpose and Scope

1. PURPOSE

This manual provides a convenient pocket reference for officers and noncommissioned officers at the platoon level. The continuing requirement of readily accessible field data, when library facilities are not available, will be fulfilled to a great extent by this manual.

2. SCOPE

a. Content. This manual contains condensed data on a wide variety of subjects pertinent to the field duties of engineer officers and noncommissioned officers. Information is presented in tables, diagrams, formulas, and written matter. Illustrations are added to supplement this instruction.

b. Application. The information in this manual is applicable to both nuclear and nonnuclear warfare.

c. Comments. Users of this manual are encouraged to submit comments or recommendations for changes to improve this manual. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons should be provided for each comment to insure understanding and proper evaluation. Comments should be forwarded directly to the Commandant, U.S. Army Engineer School, Fort Belvoir, Virginia.

Section II. References

3. MANUALS

Pertinent manuals and other military publications are listed in appendix I.

4. STANDARD AGREEMENTS

Information in this manual reflects, where appropriate, North Atlantic Treaty Organization (NATO) agreements in the form of standard agreements.

CHAPTER 2

EXPLOSIVES AND DEMOLITIONS

Section I. Use

5. CHARACTERISTICS OF EXPLOSIVES

See table I for the principal types of U.S. explosives commonly used for military purposes.

NOTE: Safety regulations will be observed in all situations to the fullest extent permitted by time, by materials available, and by requirements of the mission. The general rules apply in all cases.

a. Never handle explosives carelessly.

b. Responsibility for the preparation, placement, or firing of charges is never to be divided; one person should be responsible to supervise all phases of a demolition mission.

c. The following criteria give the missile hazard distances at which personnel in the open are safe from missiles created by bare charges placed on or in the ground, regardless of the type or condition of soil.

(1) For charges less than 27 pounds the minimum safe distance is 900 feet.

(2) For charges from 27 to 500 pounds the safe distance formula is:

$$\text{Safe distance in feet} = 300 \times \sqrt[3]{\text{pounds of explosive}}$$

(3) See table 2 for minimum safe distances for personnel in the open.

d. For further information, see AR 385-63.

6. CALCULATION OF CHARGES

Calculation of the required amount of explosives for demolition work may be quickly accomplished by the use of a formula. In this formula, the value obtained for P represents the amount of TNT (in pounds) required for a particular charge. When other explosives are used, the value of P must be adjusted in accordance with their strength. This relative effectiveness factor is used only when external charges are computed for:

a. Steel cutting.
b. Timber cutting.
c. Breaching.
d. Pressure.

Column 4 of table I gives the data on the relative strength factors of explosives. Adjustment is done by dividing the P value obtained for TNT by the relative strength factor for the explosive to be used.

7. STEEL CUTTING CHARGES

a. Formula for Structural Steel Sections. This is the grade of steel used in buildings, bridges and other steel structures. The following formula is applicable to this

steel (such as I-beams, girders, and plates) except slender bars of 2-inch diameter or less:

$P = 3/8\ A$ where P = pounds of TNT required and
A = cross sectional area, in square inches, of the steel member to be cut.

NOTE: Charges calculated from these formulas should be rounded off to the next higher unit package of the explosive. If calculations call for 3 27/64 pounds, then 4 pounds would be the correct amount of TNT to use.

b. **Formula for Other Steel Structures.** This is the recommended formula for high-carbon steel, alloy steel, structural bars of 2-inch diameter or less, chains, cables, strong forgings, machine parts, and high-strength tools:

$P = D^2$ where P = pounds of TNT and
D = diameter in inches of section to be cut.

c. **Railroad Rails.** The size of a railroad rail is expressed by the weight of 1 yard of rail: an 80-pound rail weighs 80 pounds per yard. To cut this size rail, or smaller, 1/2 pound of TNT is set against its web. For heavier rail, use 1 pound of TNT. (As a rule of thumb, a rail over 5 inches high weighs more than 80 pounds per yard.)

d. **Example:**

(1) How much TNT is required to cut the steel I-beam in figure 1?

Calculation: P = 3/8A (see a above)

Area in flanges = 2 x 1/2 in. x 5 in. = 5 sq. in.
Area in web = 3/8 in. x 11 in. = 4 1/8 sq. in.
Total area = 9 1/8 sq. in.

P = 3/8 A
P = 3/8 x 9 1/8 = 3 27/64
Use 4 pounds of TNT.

(2) How much 60 percent straight dynamite is required to cut the same I-beam (fig. 1)? Since the amount of TNT required is 3 27/64 pounds, or 219/64, and 60 percent straight dynamite is 0.83 times as effective as TNT (column 4, table 1), therefore

$$P \text{ (of 60 percent straight dynamite)} = \frac{219/64}{0.83} = 4\ 1/8 \text{ pounds.}$$

Use 9 (or possibly 8 1/2) 1/2-pound sticks of 60 percent straight dynamite.

(3) Plastic explosive is best suited for cutting steel.

e. **Example:** How much TNT is required to cut the steel chain in figure 2?

Calculation: $P = D^2$
P = 1 in. x 1 in.
P = 1 lb. of TNT

Use 1 pound of TNT at A and 1 pound at B to destroy the chain link.

Table 1. Continued

Name	Principal Use	Smallest cap required for detonation	Relative effectiveness as external charge	Velocity of detonation, fps	Value as cratering charge	Intensity of poisonous fumes	Water resistance	Packaging
Gelatin dynamite 40% 50% 60%	Land clearing, (Continued)	No. 6 commercial cap, (Continued)	0.42 0.47 0.76	8,000 9,000 16,000	Good	Slight	Good	50-lb box
PETN	Detonating cord	Special blasting cap, electric or nonelectric	1.00	21,000	NA	-do-	-do-	—
	Blasting cap	NA						
Tetryl	Booster charge	Special blasting cap, electric or nonelectric	1.25	23,400	NA	Dangerous	Excellent	—
Composition B	Bangalore torpedo	Special blasting cap, electric or nonelectric	1.35	25,000	Good	-do-	-do-	—
Amatol 80/20	-do-		1.17	16,000	Excellent	-do-	Poor	Bulk
Black Powder	Time blasting fuze	NA	0.55	Unknown	Fair	-do-	-do-	Bulk
Nitrostarch	Substitute for TNT	Special blasting cap, electric or nonelectric	0.80	—	Good	-do-	Satisfactory	1-lb blocks

Table 1. Characteristics of Principal U.S. Explosives

Name	Principal Use	Smallest cap required for detonation	Relative effectiveness as external charge	Velocity of detonation, fps	Value as cratering charge	Intensity of poisonous fumes	Water resistance	Packaging
TNT	Main charge, booster charge; cutting and breaching charge, general and military use in forward areas.	Special blasting cap, electric or nonelectric	1.00	21,000	Good	Dangerous	Excellent	½ lb, 100 to box 1 lb, 50 to box
Tetrytol, M1,M2			1.20	23,000	Fair	-do-	-do-	16 blocks in wooden box
Composition C3			1.34	26,000	Excellent	-do-	Good	16 2¼-lb blocks in wooden box
Composition C4			1.34	26,000	-do-	Slight	Excellent	24 2½-lb blocks in wooden box
Ammonium nitrate	Cratering and ditching		0.42	11,000	-do-	Dangerous	Poor	40-lb charge in metal can
Military dynamite M1	Quarry and rock cuts		0.92	20,000	Good	-do-	Good	½-lb charge
Straight 40% dynamite 50% (Commercial) 60%	Land clearing, cratering, quarrying, and general use in rear areas, such as ditching and stumping.	No. 6 commercial cap, electric or nonelectric	0.65 0.79 0.83	15,000 18,000 19,000	Good	-do-	Good, if fired within 24 hrs	50-lb box
Ammonia 40% dynamite 50% (Commercial) 60%			0.41 0.46 0.53	9,000 11,000 12,000	Excellent	-do-	Poor	-do-

Table 2. Minimum Safe Distance for Personnel in the Open

Pounds of explosive	Safe distance in meters	Pounds of explosive	Safe distance in meters
1-27	275	65	366
28	277	70	375
29	280	75	384
30	283	80	393
32	290	85	401
34	295	90	410
36	302	95	417
38	307	100	457
40	311	125	457
42	317	150	486
44	320	200	534
46	327	300	612
48	329	400	673
50	336	500	726
55	348	Over 500	732
60	357		

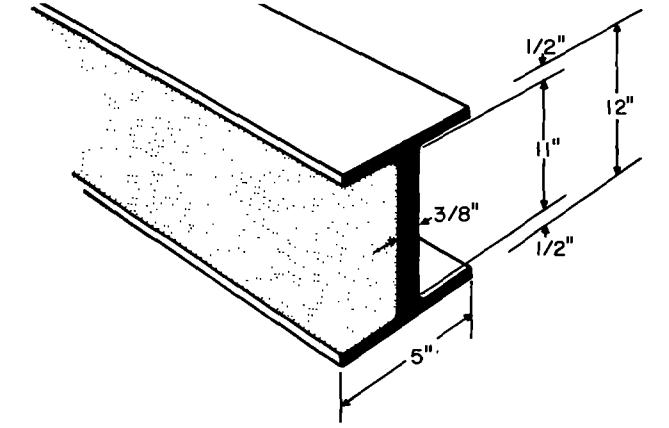


Figure 1. Calculotian of charge for cutting steel I-beam.

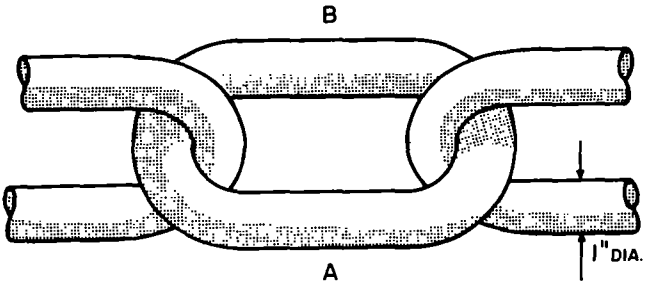


Figure 2. Steel chain.

f. Teble. See table 3 for ameunt of TNT required te cut different rectangular steel sectiens.

Table 3. Cutting Chorges For Rectangular Steel Section

Average Thickness ef Sectian in Inches	Paunds ef TNT for Rectenguler Steel Sectiees ef Given Dimensiens												
	Width ef Sectien in Inches												
	2	3	4	5	6	8	10	12	14	16	18	20	24
¼	.2	.3	.4	.5	.6	.8	1.0	1.2	1.3	1.5	1.7	1.9	2.3
3/8	.3	.5	.6	.7	.9	1.2	1.4	1.7	2.0	2.3	2.6	2.8	3.4
½	.4	.6	.8	1.0	1.2	1.5	1.9	2.3	2.7	3.0	3.4	3.8	4.5
5/8	.5	.7	1.0	1.2	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.7	5.7
¾	.6	.9	1.2	1.4	1.7	2.3	2.8	3.4	4.0	4.5	5.1	5.7	6.8
7/8	.7	1.0	1.4	1.7	2.0	2.7	3.3	4.0	4.6	5.3	6.0	6.6	7.9
1	.8	1.2	1.5	1.9	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5	9.0

TO USE TABLE:
1. Measure rectangular sectiens ef member seperately.
2. Using teble, find cherge for eech sectien.
3. Add cherges for sectiens te find tetel cherge.
4. Never use less than calculeted cherge.

8. TIMBER-CUTTING CHARGES

a. Requirements. Different types of timber in various localities require varying amounts of explosive to cut them. Hardwoods and fibrous woods (coconut) require more explosive than softwoods. Therefore, no single formula for cutting is practical; test shots should determine the specific amount of explosive required for a specific type of timber.

b. For Untamped External Charges. To cut trees, piles, posts, beams, or other timber, the following formula is the test shot.

$$P\ (TNT) = \frac{D^2}{40}$$

where P (TNT) = pounds of TNT required and
D = diameter of timber in inches.

For other explosives, adjustments for P are made according to table 1.

c. For Cutting Trees to Create an Obstacle. To cut trees and leave them attached to their stumps, the following formula is used to compute the TNT needed for a test shot.

$$P = \frac{D^2}{50}$$

where P = pounds of TNT needed and
D = diameter of timber in inches.

The result determines whether or not to increase the explosive for subsequent shots.

d. For Tamped Internal Charges. The following formula applies:

$$P = \frac{D^2}{250}$$

where P = pounds of any type explosive and
D = diameter or least cross-sectional dimension in inches of dressed timber.

e. Table. Use table 4 as a guide for both internal and external timber-cutting charges.

Table 4. Timber Cutting Charges

Type of Charge	Explosive	Charge Unit	Least Dimension of Timber in Inches									
			6	8	10	12	15	18	21	24	30	36
			Block or Pounds of Explosives									
Internal	Any	lb.	½	½	½	1	1	1½	2	2½	4	6
External	TNT	lb.	1	2	2½	4	6	9	11	15	23	33

9. PRESSURE CHARGES

a. Use. Pressure charges are effective against simple span, reinforced concrete T-beam bridges.

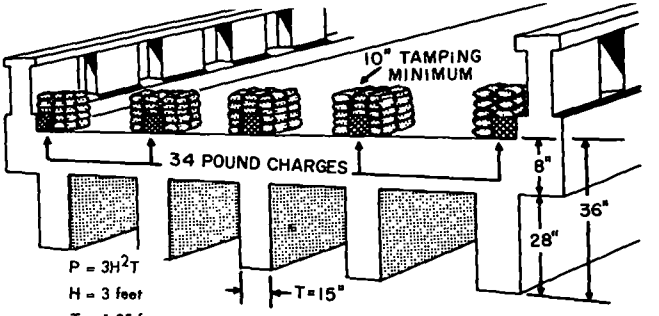
b. For Tamped Pressure Charges. To determine the amount of TNT required, use the following formula:

$P = 3H^2T$ where P = pounds of TNT required for each stringer
H = height of stringer (including thickness of roadway) in feet, and
T = thickness of stringer in feet.

If H and T are not whole numbers, round them off to the next quarter-foot dimension. Neither is ever considered to be less than 1 in the formula.

c. For Untamped Pressure Charges. Increase the calculated value of P by one-third in the above formula if the pressure charge is not tamped. A minimum of 10 inches of tamping is required.

d. Example. How much TNT is required to destroy the bridge span in figure 3? The amount is calculated in figure 3.



Use 34 pounds of TNT for each charge

Figure 3. Calculation and placement of pressure charges.

Table 5. Pressure Charges

Height of Beam in Feet	Pounds of TNT for Each Beam (Tamped Charges)								
	Thickness of Beam in Feet								
	1	1¼	1½	1¾	2	2¼	2½	2¾	3
	12 in.	15 in.	18 in.	21 in.	24 in.	27 in.	30 in.	33 in.	36 in.
1 (12 in.)	3								
1¼ (15 in.)	5	6							
1½ (18 in.)	7	9	11						
1¾ (21 in.)	10	12	14	16					
2 (24 in.)	12	15	18	21	24				
2¼ (27 in.)	16	19	23	27	31	35			
2½ (30 in.)	19	24	29	33	38	43	47		
2¾ (33 in.)	23	29	34	40	46	51	57	63	
3 (36 in.)	27	34	41	48	54	61	68	75	81
3¼ (39 in.)	32	40	48	56	64	72	80	88	95
3½ (42 in.)	37	46	56	65	74	83	92	101	111
3¾ (45 in.)	43	53	64	74	85	95	106	116	127
4 (48 in.)	48	60	72	84	96	108	120	132	144
4¼ (51 in.)	55	68	82	95	109	122	136	149	163
4½ (54 in.)	61	76	92	107	122	137	152	169	183
4¾ (57 in.)	68	85	102	119	136	153	170	187	203
5 (60 in.)	75	94	113	132	150	169	188	207	225

e. Continuous Bridge Spans. For concrete stringer bridges of continuous spans, charges are calculated by the breaching formula (par. 10b) and placed under the bridge. Charges should be so placed and calculated to insure that the breaching radius or radii will cause a complete severance of the cross section.

f. Beams. For cutting beams, see table 5.

10. BREACHING CHARGES

a. Use. Breaching charges have their most important use in the destruction of bridge piers, bridge abutments, and field fortifications of a permanent type, or to breach walls and blow holes in concrete slabs or roadways.

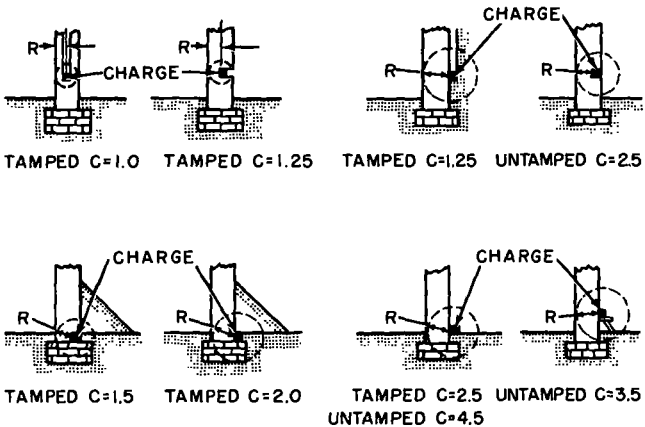


Figure 4. Values of C (tamping factor) for breaching charges.

b. Formula. $P = R^3KC$

where P = pounds of TNT required,
R = breaching radius in feet,
K = material factor (table 8) which indicates strength and hardness of material to be demolished. (When it is not known whether or not concrete is reinforced, it is assumed to be reinforced.)
C = tamping factor (fig. 4).

NOTE: To breach walls 1 foot thick and under, increase the total calculated charge by 50 percent. Add 10 percent for charges under 50 pounds. For external charges, use at least 5 pounds for reinforced concrete and at least 3 pounds for dense concrete.

c. Tables. See table 6 for the breaching of masonry items other than reinforced concrete. For reinforced concrete breaching, see table 7.

d. Number of Charges. To demolish a pier, slab, or wall, use this formula:

$N = \frac{W}{2R}$ where N = number of charges,
W = width of pier, slab, or wall, in feet, and
R = breaching radius in feet.

Table 6. Breaching Charges
(For Masonry Items Other Thon Reinforced Concrete)

Canversian Factors				
Thickness	Earth	Paar Masonry, Shale, Hardpon, Good Lumber, and Earth Constr. (Bunkers)	Good Masonry, Ordinory Concrete, Rock	Dense Concrete, First-Class Masonry
Less thon 3 feet thick	.1	.5	.5	.6
3 feet to less than 5	.1	.5	.5	.7
5 feet to less than 7	.1	.5	.5	.7
7 feet or more	.1	.5	.55	.7

TO USE TABLE:

1. Determine the type of materiol in the object you plan to destroy. If in doubt, assume the material to be of the stronger type.
2. Measure thickness of moteriol.
3. Using obove toble, determine conversion foctor.
4. Using toble 7, determine omount of TNT required if object were mode of reinforced concrete.
5. Multiply number of pounds of TNT (from toble 7) by the conversion foctor from above toble.

When the colculoted volue of N contoins o froction less thon 1/2, the froction is disregarded; if 1/2 or more, round off to next higher figure. Exception: in N volues between 1 ond 2, fractions less thon 1/4 ore disregorded; 1/4 or more is rounded off to whole number of 2.

e. Example. Find the number ond size of TNT chorges to breach o bridge pier, dense concrete, or first-closs mosonry, charges placed at ground level, tomped.

No. of Charges	Size of Charges
$N = W/2R$	$P = R^3 KC$
$W = 30$ ft.	$R = 9$ ft.
$R = 9$ ft.	$K = 0.28$ (table 8)
$N = \frac{30}{2 \times 9} = 1.67$	$C = 2.5$ (fig. 4)
(Use two charges)	$P = 9^3 \times 0.28 \times 2.5 = 510.3$ (Use 511 pounds of TNT for each charge.)

Table 7. Reinforced Concrete Breaching Charges

Thickness of Concrete in Feet	Pounds of TNT					Distance Between Charges in Feet*	
Column	1	2	3	4	5	6	7
2	16	28	22	8	1	2	4
2½	31	55	43	16	2	2½	5
3	41	67	52	21	4	3	6
3½	59	107	83	33	6	3½	7
4	88	159	124	49	8	4	8
4½	126	226	176	63	11	4½	9
5	157	282	219	79	16	5	10
5½	208	375	292	104	20	5½	11
6	270	486	378	135	21	6	12
6½	344	618	481	172	26	6½	13
7	369	664	517	185	33	7	14
7½	445	817	635	227	40	7½	15
8	551	991	771	276	49	8	16

*See Note for Table 8.

f. Breaching Hard-Surface Pavements.

(1) A hard-surface pavement is breached so that holes can be dug for cratering charges. Use a 1-pound charge of explosive for each 2 inches of pavement thickness, with tamping twice as thick as the pavement.

(2) Pavement may be breached by charges placed in boreholes drilled or blasted through the pavement. A shaped charge readily blasts a small diameter borehole through the pavement and into the subgrade. Concrete should not be breached at an expansion joint because the concrete will then shatter on only one side of the joint.

Table 8. Values of Material Factor K for Use in Calculating Breaching Charges

Material	R (breaching radius)*	K
Ordinary earth	All values	0.05
Poor masonry, shale, and hard-pan, good timber and earth construction	All values	0.23
Good masonry, ordinary concrete, rock	Less than 3 ft 3 ft to less than 5 ft 5 ft to less than 7 ft 7 ft or more	0.35 .28 .25 .23
Dense concrete, first-class masonry	Less than 3 ft 3 ft to less than 5 ft 5 ft to less than 7 ft 7 ft or more	0.45 .38 .33 .28
Reinforced concrete (for concrete only; will not cut reinforcing steel)	Less than 3 ft 3 ft to less than 5 ft 5 ft to less than 7 ft 7 ft or more	0.70 .55 .50 .43

*Distance (in feet) from the explosive, within which all material is displaced or destroyed. For external charges, the thickness of the mass to be breached may be taken. For internal charges, take one-half of thickness of mass to be breached if charge is placed midway into mass. If holes are drilled less than halfway into mass, the breaching radius is the longer distance from center of drill hole to outside of mass, e.g., to breach 4-foot wall by internal charge placed 1 foot into mass; breaching radius is 3 feet.

11. CRATERING CHARGES

a. Requirements. To be effective obstacles, road craters must be too wide to be spanned by scissor-type bridges, and too deep and too steep sided for vehicles to pass through them. They must be large enough to tie into either natural or man-made obstacles at each end. See figures 5 and 6 for details of placement.

b. Road Cratering at Culverts.

(1) Culverts covered with less than a 5-foot fill may be destroyed and a crater formed by explosives placed the same as for hasty road cratering. Place concentrated charges equal to 10 pounds per foot of depth in boreholes at 5-foot intervals in the fill above and alongside the culvert.

(2) Culverts covered with from 5 feet to 15 feet of fill are destroyed by charges placed inside the culvert against its roof at intervals equal to 4/5 D

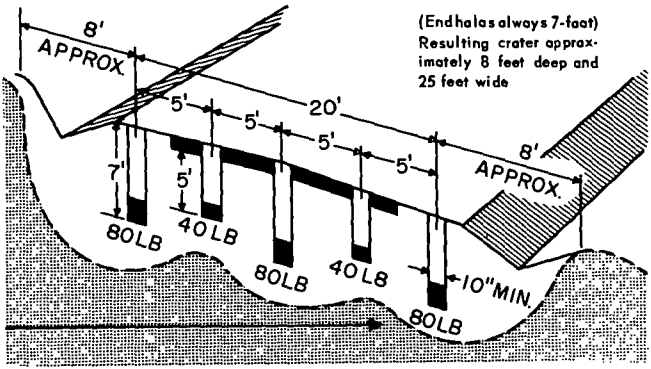


Figure 5. Placement of charges for deliberate road crater.

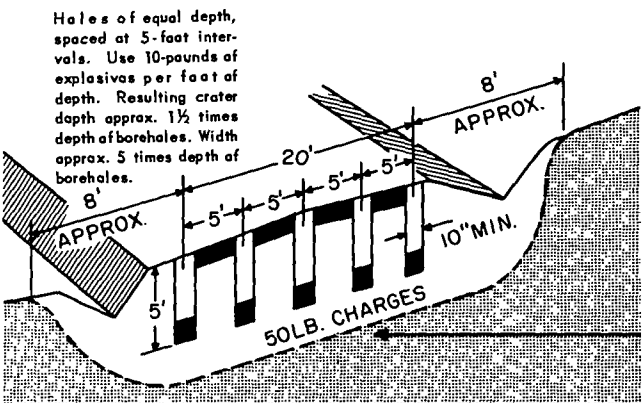


Figure 6. Placement of charges for hasty road crater.

To calculate size of charges:

Charges A and B:

$P = 2D^2 = 2 \times 15^2 = 450$ pounds in each charge

Charges C:

$P = 2D^2 = 2 \times 8^2 = 128$ pounds in each charge

Charges D:

$P = 10D = 10 \times 4 = 40$ pounds in each charge

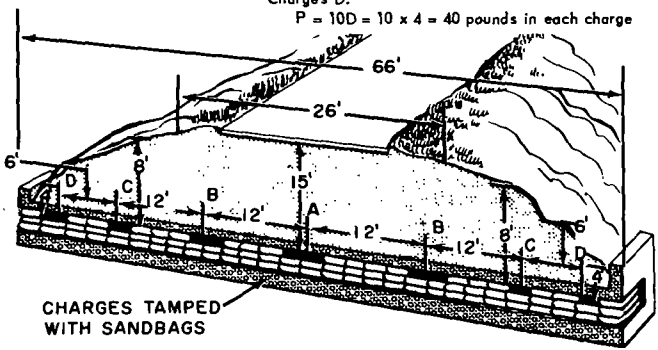


Figure 7. Placement of cratering charges in a culvert.

(fig. 7). Base calculations on this formula: $P = 2D^2$

where P = pounds of explosive per charge and
D = maximum depth in feet at which charge is placed.

Charges under the shoulder of the road, where depth is 5 feet or less, are calculated on the basis of 10 pounds of explosive per foot of depth of shoulder. Space these charges 5 feet apart.

c. Antitank Ditch Cratering.

(1) The deliberate cratering method as outlined in b above is suited for heavy tank antitank ditches. This method gives a V-shaped crater about 2.5 meters deep and 7.5 meters wide.

(2) For hasty cratering against medium tanks, place 40 pounds of cratering explosive (ammonium nitrate) in 4-foot holes spaced 5 feet apart. This gives a ditch about 6 feet deep and 20 feet wide. Against heavy tanks, place 50 pounds of cratering charge in 5-foot holes 5 feet apart. The resulting ditch will be about 8 feet deep and 25 feet wide.

(3) To ensure against misfires, all cratering charges must have an additional primer—a one-pound charge placed on top of each cap and incorporated into a dual firing system.

(4) Rule of thumb for number of holes:

$$N = \frac{L - 16}{5} + 1$$

d. Shaped Charges. Table 9 shows the size of boreholes obtained in concrete, armor, ice, and permafrost by using the standard M3 (40-pound) and M2A3 (15-pound) shaped charges.

Table 9. Sizes of Boreholes

Material	Information needed		M3 (40-lb) shaped charge	M2A3 (15-lb) shaped charge
Reinforced concrete	Maximum wall thickness which can be perforated		60 in	36 in
	Depth of penetration in thick walls		60 in	30 in
	Diameter of hole	Entrance	5 in	3½ in
		Average	3½ in	2¾ in
		Minimum	2½ in	2 in
	Depth of hole with second charge placed over first hole		84 in	45 in
Armorplate	Perforation		At least 20 in	12 in
	Average diameter of hole		2½ in	1½ in
Permafrost	Depth of hole with 50-in standoff		72 in	NA
	Depth of hole with 30-in standoff		NA	72 in
	Depth of hole with 42-in standoff		NA	60 in
	Diameter of hole with average (30 in) standoff		NA	6 to 1½ in
	Diameter of hole with 50-in standoff		8 to 5	NA
	Diameter of hole with normal standoff		26-30 to 7 in	26-30 to 4 in
Ice	Depth with average (42 in) standoff		12 ft	7 ft
	Diameter with average (42 in) standoff		6	3½ in

Section II. Demolition by Explosives

12. DEMOLITION SETS

Demolition sets ore composed of demolition explosive items, occessories, ond tools.

a. **Demalitian Equipment Set, Explosive Initiating, Electric ond Nonelectric.**

(1) This electric and nonelectric demalition equipment set comprises TNT ond composition C4 demolition blacks, and accessaries for electric and nonelectric priming.

(2) Components ond quantity in eoch set are as follows (N indicates non-expendoble):

Components (nonexplosive)		Quantity
Adopter, primary.	——	60
Adhesive, poste, 1/2-lb can.	——	2
Bag, canvas, carrying: demolitian equipment.	——	2
Blosting machine: hond operated, 10-cap capacity.	N	1
Box, cap: 10-cap capacity.	——	5
Cable, power, electrical, 500 ft.	——	1
Chest, demolitian.	N	1
Clip, cord.	——	50
Crimper, cap: M2 w/fuze cutter.	——	2
Galvanometer, blosting.	N	1
Insulatian tope, electrical, roll.	——	6
Knife, pocket.	——	2
Pliers, lineman's.	——	2
Reel, wire, firing, 500 ft.	——	1
Seoling compound, 1/2 pt can.	——	1
Tope, computing.	N	2
Twine, ball.	——	2
Wire, electrical, 200 ft.	——	2
Compan ents (explosive)		**Quantity**
Cap, blasting, electric.	——	50
Cop, blasting, nonelectric.	——	50
Chorge, demolition, comp C-4.	——	40

Charge, demolition, TNT.	____	50
Cord, detonating, primacord, 50 ft.	____	1
Destructor, explosive.	____	5
Fuze, blasting, time, 100 ft.	____	1
Igniter, blasting fuze, M2.	____	50

Each component is a single unit of issue.

b. **Demolition Equipment Set, Explosive Initiating, Nonelectric**

(1) This nonelectric demolition equipment set consists of composition C4 demolition blocks, and accessories for nonelectric priming.

(2) Components and quantity in each set are listed as follows (N = nonexpendable):

Components (nonexplosive)	Quantity	
Adapter, priming.	____	20
Adhesive, paste, 1/2-lb can.	____	2
Bag, canvas, carrying.	____	2
Box, cap, 10-cap capacity.	____	2
Clip, cord.	____	50
Crimper, cap: M2 w/fuze cutter.	____	2
Insulation tape, electrical, roll.	____	2
Knife, pocket.	____	2
Sealing compound, 1/2-pt can.	____	1
Tape, computing.	N	2

Components (explosive)	Quantity	
Cap, blasting, nonelectric.	____	50
Charge, demolition, comp C-4.	____	40
Cord, detonating, primacord, 200 ft.	____	1
Destructor, explosive.	____	2
Fuze, blasting, time, 100 ft.	____	1
Igniter, blasting, fuze, M2	____	50

Each component is a single unit of issue.

c. Demolition Assembly Charge, M37. Here are eight composition C4 demolition blocks, eight demolition block hook assemblies, and two M15 priming assemblies.

13. TUNNELS

a. Hasty Demolitions. Reasonable amounts of conventional high explosives are ineffective in hasty demolition of tunnels; no hasty method has been devised to cause extensive damage to a tunnel. The tunnel may be rendered useless temporarily by dislodging part of the lining with normal breaching charges at a number of points, or by creating slides at the portals with cratering charges placed in the slopes above. Nuclear devices of proper size placed advantageously provide a means for complete tunnel demolition.

b. Deliberate Demolitions.

(1) Detonate charges in prepared chambers in the media next to the inner face of the tunnel whether or not the tunnel is lined. Each charge chamber parallels the long axis of the tunnel at or above the spring line (fig. 8).

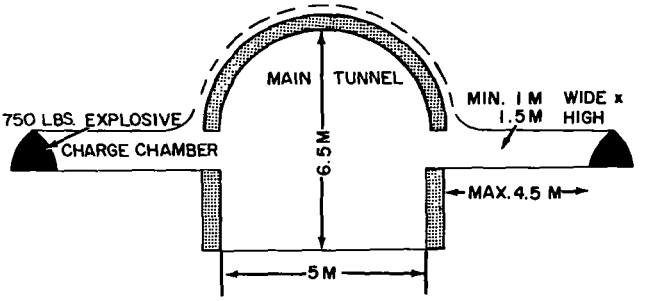


Figure 8. Charge chambers dug at spring line for tunnel demolition.

(2) The T-type charge chamber (fig. 8) inflicts serious damage to a tunnel. These chambers may be opposite each other, may be staggered, or may be all on one side. The distance from the inside rock wall is 15 feet. The chamber should be large enough for convenient construction and loading and no smaller than 3 1/2 feet wide by 4 1/2 feet high. Other dimensions in sizes of charges are shown in figure 9.

(3) Stemming, the material which fills the boreholes or charge chamber is necessary (fig. 9). It is not necessary between charges within the chamber.

(4) In some tunnels there are chambers or holes constructed in the roof for demolishing the tunnel in the future. They usually have open, brick ventilators over them. If ventilators are not detected, strike roof of tunnel with a heavy object until a hollow sound is heard. When charge chambers are located, explosives are set in them as tightly as possible. Sandbag stemming is recommended in timber tunnels, it tends to cause tunnel timbers to ignite when charge is detonated.

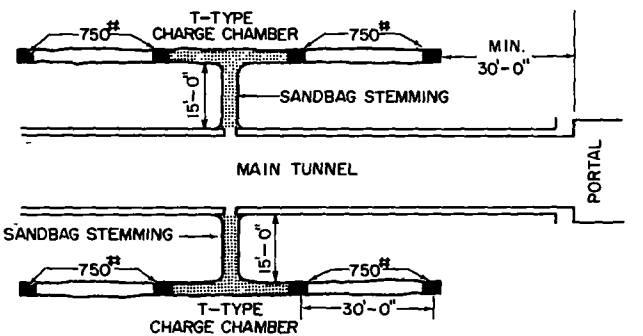


Figure 9. Detail for tunnel demolition.

14. BRIDGE ABUTMENTS

Placing charges in the fill behind an abutment is economical in explosives and conceals the charges from the enemy.

a. Abutments 5 Feet Thick or Less. Place 40-pound cratering charges in holes 5 feet deep and 5 feet behind the river face of the abutment, beginning with a hole placed 5 feet in from one side of the road (fig. 10). To calculate the number of boreholes, use the formula written in figure 10.

b. Abutments More Than 5 Feet Thick. Place breaching charges in contact with rear face of abutment (fig. 11). Calculate the size of charges by the formula in figure 11. Charges are placed at a depth greater than or equal to R. The spacing and number of charges are determined by the calculations explained in paragraph 10. To calculate the number of charges, see the formula in figure 11.

c. Combination Charges. Place a combination of external breaching charges (along

Beginning 5 feet in from the side of the road, place 40-pound cratering charges in holes 5 feet deep, 5 feet on centers and 5 feet behind the river face of the abutment.

Formula: $N = \frac{W}{5} - 1$

where N = no. of boreholes
W = width of abutment

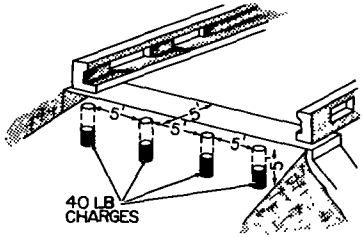


Figure 10. Charges placed in the fill behind a reinforced concrete abutment less than 5 feet thick.

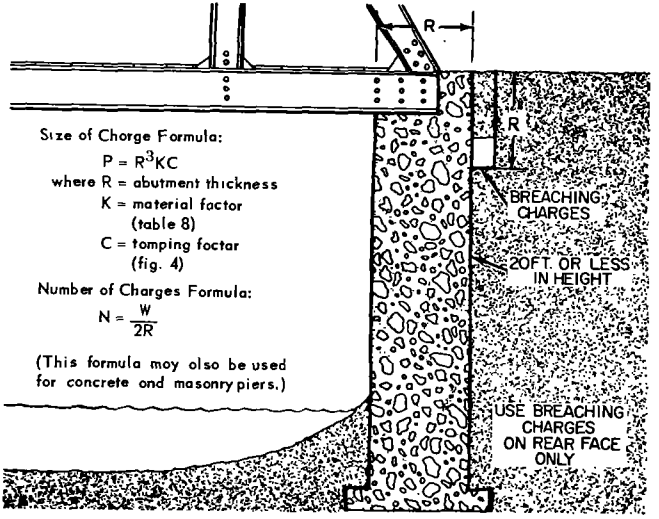
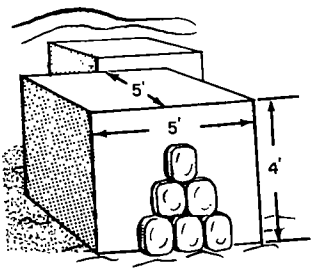
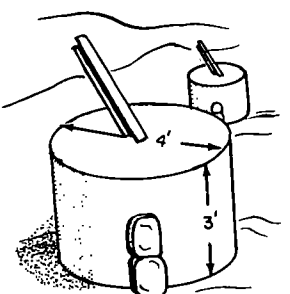


Figure 11. Charges in the fill behind a reinforced concrete abutment more than 5 feet thick.

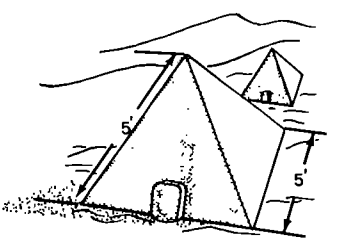


CUBE
CHARGE: 120 LB

SMALL DRAGON'S TOOTH
CHARGE: 20 LB



CYLINDER
CHARGE: 40LB.



TETRAHEDRON
CHARGE: 20LB.

Figure 12. Explosive packs needed to destroy typical small concrete obstacles.

bottom of abutment) and fill charges (behind the abutment) to destroy abutments more than 20 feet high. Fire them simultaneously. The fill charges may be calculated according to the formula:

$N = \frac{W}{5} - 1$ or according to $P = R^3KC$, depending upon the abutment thickness.

15. CONCRETE OBSTACLES

a. Small Obstacles. For small obstacles such as those found on beaches, use hand-placed charges. As depicted in figure 12, use 1 pound of military explosive per cubic foot of reinforced concrete.

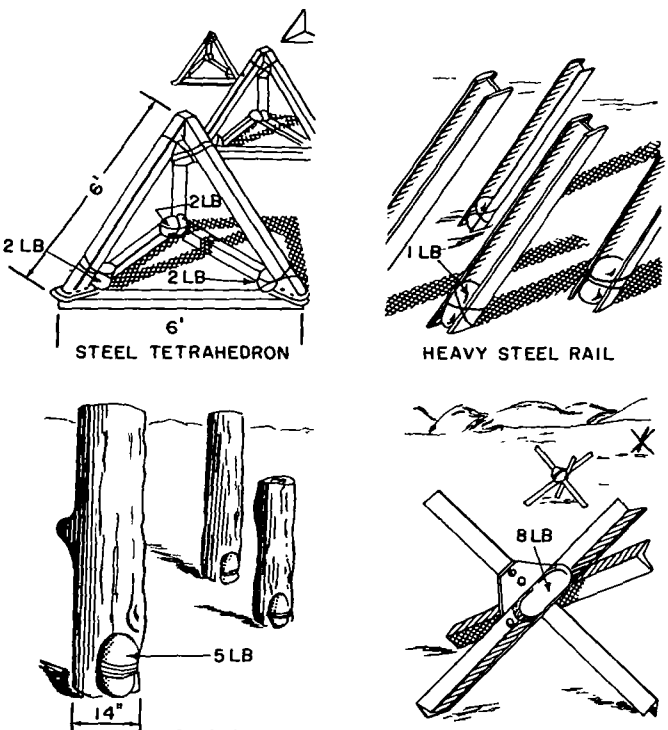


Figure 13. Placement of charges for destruction of steel and log obstacles.

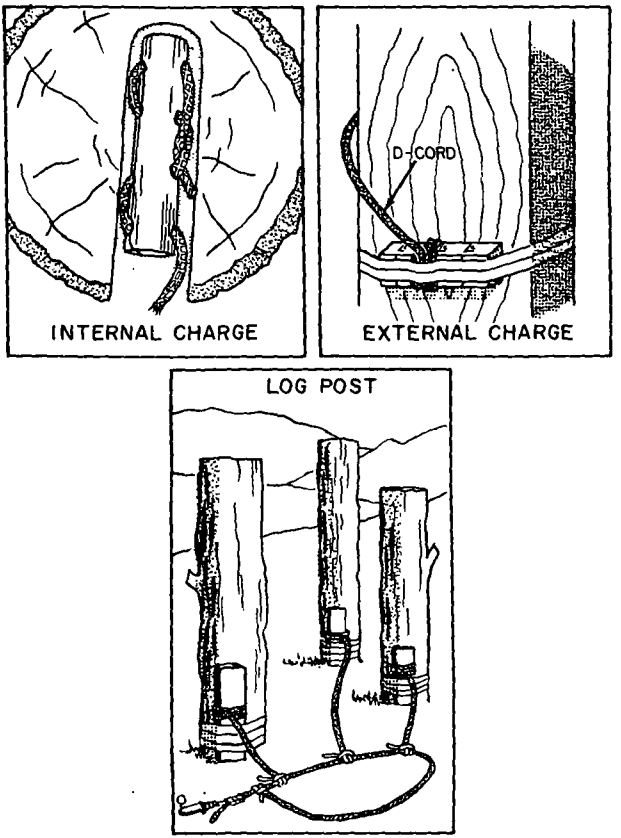
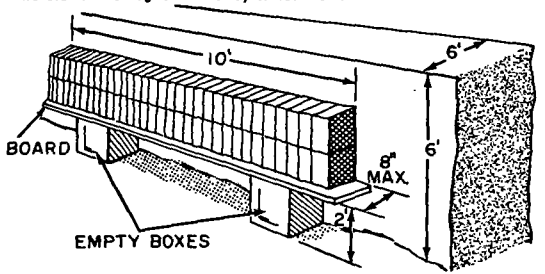


Figure 14. Size and placement of charges used against common wooden obstacles.

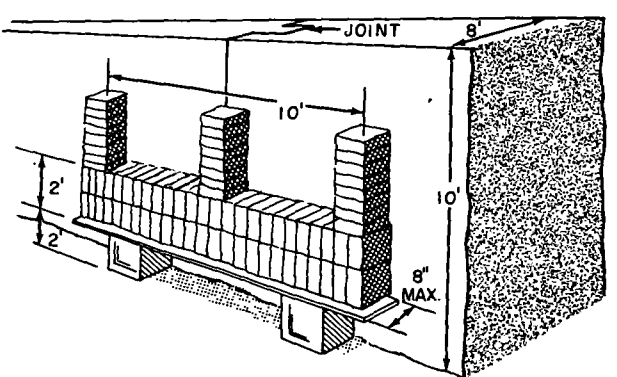
b. Larger Obstacles. For larger obstacles, place and explode the charges in two or more successive stages, and by blasting boreholes for internal charges. Use about 2 pounds of explosive per cubic foot of obstacle.

16. STEEL AND LOG OBSTACLES

a. Placement. The illustrations in figure 13 show several obstacles and the placement and sizes of charges to destroy or cut them.



(1) CHARGE: 1000 LB.



(2) CHARGE: GREATER THAN 1000 LB.

Figure 15. Placement of charges for wall 6 feet thick and for wall over 6 feet thick.

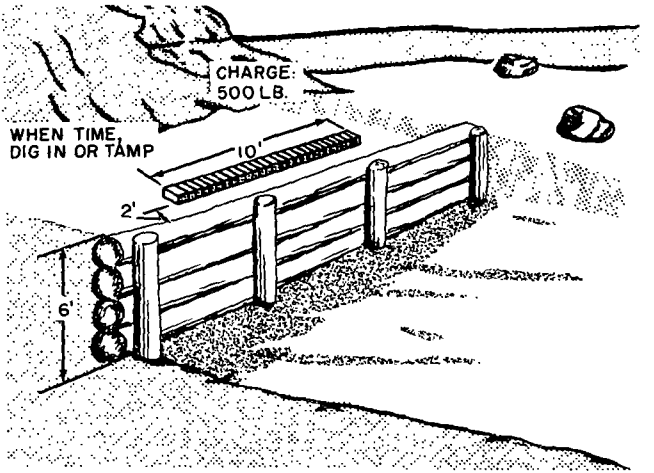


Figure 16. Breaching a backfilled log wall.

b. Charges for Log Obstacles. Examples of the sizes and placement of charges for typical log obstacles are shown in figure 14. Generally, the charge should be placed at a joint where the obstacle is weakest. Against log cribs place 30 to 40 pounds of explosive in the center of the earth fill two-thirds the depth of the crib and tamp thoroughly. Similar charges are placed on 8-foot centers for the full length of the crib. Demolition snakes may also be used to clear a path through a field of wooden posts. Log scaffolding (often under water) is destroyed by tying three 15-foot lengths of bangalore torpedo together and placing them at right angles to the line of scaffolding. This clears a lane 12 feet wide. Charges placed on obstacles driven into the ground should be attached below or as close to the surface of the ground as possible.

17. WALLS

a. Concrete Walls not Backfilled. On walls up to 6 feet high and 6 feet thick, use 160 pounds of explosive per foot of thickness. For larger walls, add 80 pounds of explosive for each additional foot of height or thickness. Example: For a wall 8 feet thick and 10 feet high, (6 x 160) + (4 x 80) + (2 x 80) = 1,440 pounds. The positions, amounts, and patterns of charges are shown in figure 15.

b. Backfilled Walls.

(1) Concrete. Increase by 20 percent the charges specified for walls not backfilled. On some walls where this may not be enough, use a second shot or clear with dozers or hand labor.

(2) Logs. Place a 500-pound charge 10 feet long on top of the wall 2 feet from the face (fig. 16).

Section III. Constructive Use of Explosives

18. QUARRYING

a. Multiple-Bench Method. Military quarries are usually developed by the multiple-bench method (fig. 17).

b. Spacing Boreholes. There is a relationship between the burden, which is the distance from the row of boreholes to the free face (fig. 18), and the spacing of boreholes in a row. This spacing also depends upon the type of boreholes, of which there are two:

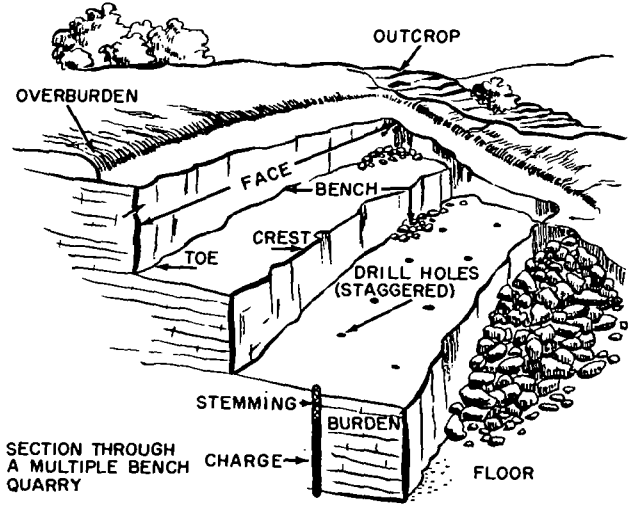


Figure 17. Multiple-bench quarry.

Figure 18. Arranging parallel rows of vertical holes.

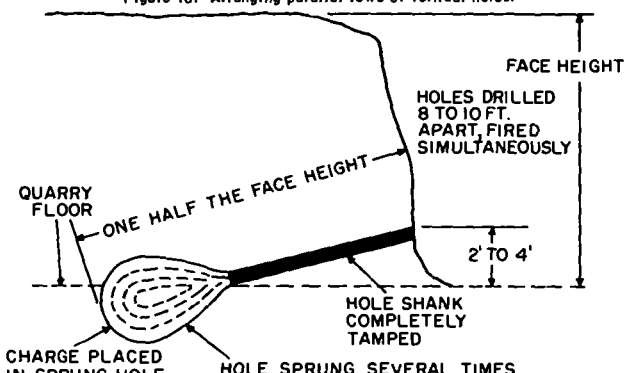

FACE HEIGHT
HOLES DRILLED 8 TO 10 FT. APART, FIRED SIMULTANEOUSLY
ONE HALF THE FACE HEIGHT
QUARRY FLOOR
2' TO 4'
HOLE SHANK COMPLETELY TAMPED
CHARGE PLACED IN SPRUNG HOLE
HOLE SPRUNG SEVERAL TIMES

Figure 19. Snakeholing.

(1) Vertical holes. The depth of vertical holes is limited by depth of rock, the length of drill, and drilling equipment. Spacing is equal to, or a little more than, the burden. When several rows are drilled, the spacing of the rear rows is 10 percent less than in the front row (fig. 18).

(2) Snakeholes. Drill at base of quarry face and begin from 2 to 4 feet above the floor. Slope each hole downward at the same angle so that the end of the hole is level with the quarry floor. Burden will equal one-half the height of face, with spacing between 8 and 10 feet (fig. 19). Snakeholes are sprung by drilling to the desired depth, then firing a small springing charge at the bottom of the borehole to form a chamber in which the larger charge is placed.

c. Amount of Explosives. An approximate amount of explosives per foot of borehole is shown in table 10.

19. ROCK EXCAVATION

a. Overburden. After the quarry layout has been decided upon, the work of removing the overburden should be started as soon as possible.

b. Blasting.

(1) Benching. Excavation is done as described in paragraph 18, above.

(2) Well holes. Use well holes to bring through cuts or sidehill cuts to grade with one shot by drilling ahead of power shovel. When the whole cut cannot be blasted at once, drill boreholes 100 to 150 feet ahead of the shovel and blast four or five rows at a time (fig. 20).

(3) Snakeholes. Use snakeholes to widen cuts (fig. 21). Drill them on 5-foot centers and wherever possible fire them simultaneously.

c. Explosive Charge. Determine weight of explosive charge required per borehole by test shots. Ten to twenty percent overcharge makes shoveling faster and minimizes redrilling and reshooting. Table 10 gives the explosive capacity per foot of borehole of various sizes.

20. DITCHING

a. Conditions. Rough, open ditches 2 1/2 to 12 feet deep and 4 to 40 feet wide can be blasted in most types of soil, except in gravel and sand. Trees, stumps, and large boulders are charged separately, but are fired simultaneously with the ditching charges.

b. Test Shots. Before beginning the ditching, run test shots to determine the proper depth, spacing, and weight of charges for desired results. Begin with holes 2

Table 10. Amount of Explosives to Use in Boreholes

Diameter of borehole, in.	Explosive per ft., lbs*	Diameter of borehole, in.	Explosive per ft., lbs*
1 1/2	0.65	5	7.40
1 3/4	0.90	5 1/2	8.30
2	1.20	5 5/8	9.35
2 1/2	1.85	6	10.60
3	2.70	6 1/2	12.50
3 1/2	3.65	7	14.50
4	4.75	8	18.90
4 1/2	5.95		

NOTE: Explosive in 2/3 depth of hole, stemming in 1/3 depth.

* Estimates are based on military dynamite in troprack. For further information on quarrying, see TM 5-250.

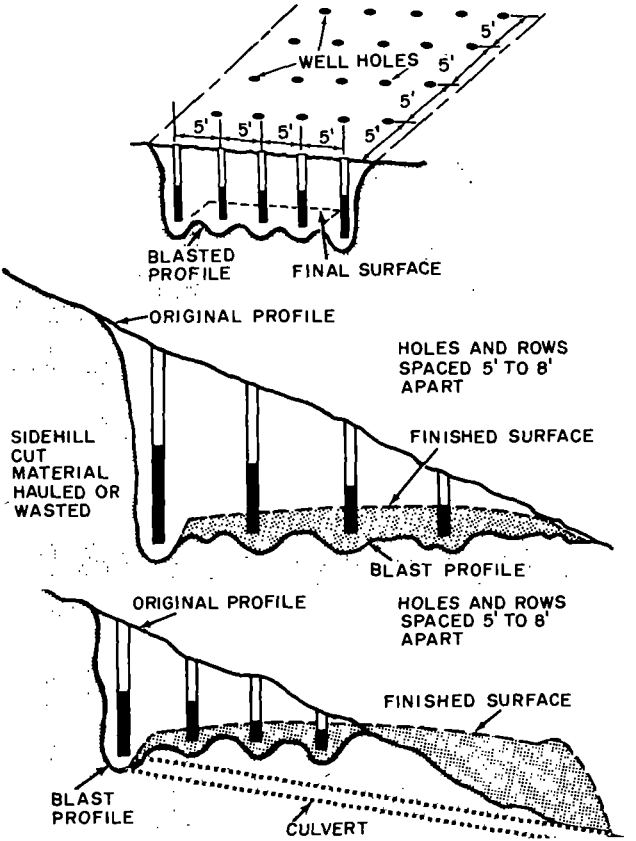


Figure 20. Benching.

feet deep and 18 inches apart for small ditches and increase in charges and depth as required (fig. 22). Average size ditches obtained with various charges are seen in table 11.

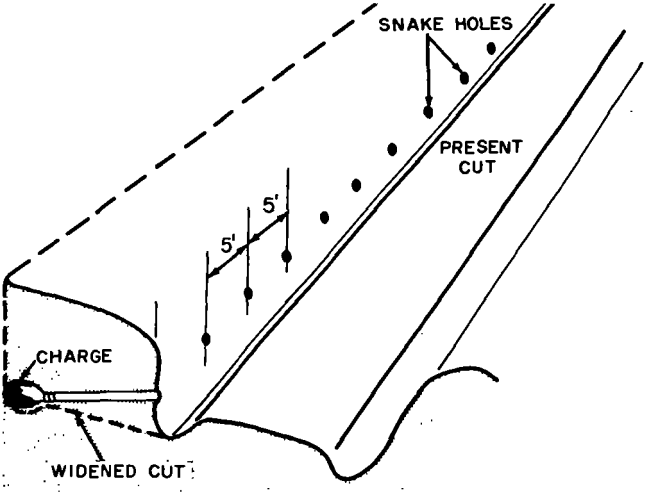


Figure 21. Snakeholes.

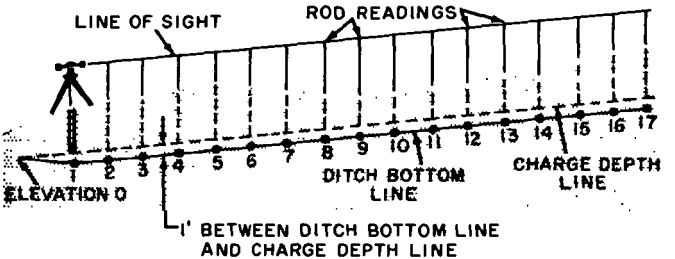

LINE OF SIGHT
ROD READINGS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
ELEVATION 0
DITCH BOTTOM LINE
CHARGE DEPTH LINE
1' BETWEEN DITCH BOTTOM LINE AND CHARGE DEPTH LINE

Figure 22. Charge holes set by transit line.

Table 11. Example Charge Points (Elevations Exaggerated for Clarity)

(1) Charge point	(2) Ditch-bottom line elevation, ft	(3) Charge-depth-line elevation, ft	(4) Line-of-sight elevation, ft	(5) ROD reading, ft	(6) Ground elevation (4)-(5)=(6), ft	(7) Depth of hole (6)-(3)=7, ft
1	0	1	9	5.0	4.0	3.0
5	1	2	10	4.8	5.2	3.2
9	2	3	11	6.7	4.3	1.3
13	3	4	12	7.0	5.0	1.0
17	4	5	13	5.0	8.0	3.0

c. Alinement and Grade. Mark ditch centerlines by chalk or transit line, and by drilling holes along it. When a transit is used, the grade of the ditch can be accurately controlled by checking the hole depth every 5 or 10 holes and at each change in grade. Drill holes in soft ground with sharp punch or quicksand punch (fig. 23). Load and tamp them immediately to prevent cave-ins and insure charge is at proper depth.

d. Detonation Methods.

(1) Propagation methods. Prime the hole, or holes, at one end of the proposed ditch; concussion will set off the succeeding charges. Use straight dynamite. It works in moist soils, particularly in swamps containing stumps with the ground under several inches of water (fig. 24). If more than one line of charges is used to obtain a wide ditch, each line is primed. Overcharge the primed hole 1 or 2 pounds.

(2) Electrical method. Use any high explosive in this method of ditching, and in any soil regardless of moisture. Prime each charge with an electric cap. Blow all charges simultaneously (fig. 25).

(3) Detonating cord method. Use any high explosive with this method. This method is effective in any soil except sand and gravel, regardless of the amount of moisture. Each charge is primed with detonating cord and connected to a ring main.

e. Loading Methods.

(1) The method of loading for a deep, narrow ditch is pictured in figure 26.

(2) The relief methodof looding for shollow ditches is depicted in figure 27. Ditches 1 ond 3 ore blosted first to relieve the chorge in ditch 2.

(3) Figure 28 shows the posthole method of looding for shallow ditches in the mud.

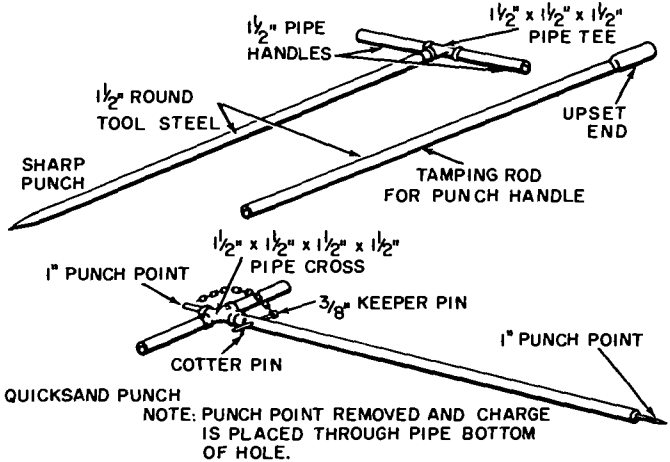

1½" PIPE HANDLES
1½" x 1½" x 1½" PIPE TEE
1½" ROUND TOOL STEEL
UPSET END
SHARP PUNCH
TAMPING ROD FOR PUNCH HANDLE
1½" x 1½" x 1½" x 1½" PIPE CROSS
1" PUNCH POINT
3/8" KEEPER PIN
1" PUNCH POINT
COTTER PIN
QUICKSAND PUNCH
NOTE: PUNCH POINT REMOVED AND CHARGE IS PLACED THROUGH PIPE BOTTOM OF HOLE.

Figure 23. Punches used to ploce chorges ot proper depths in soft ground.

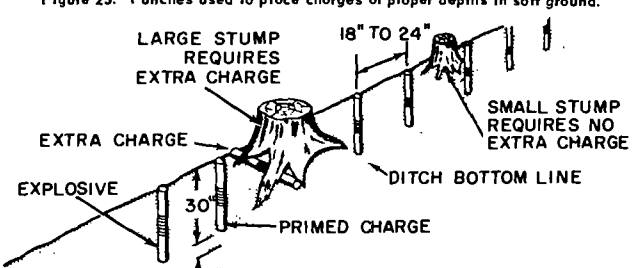


Figure 24. Propagation method of detonotion.

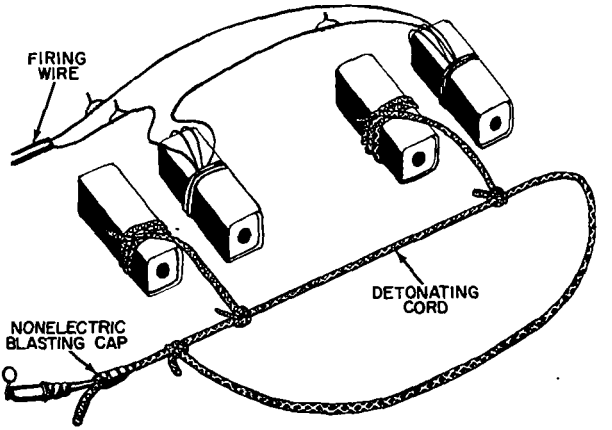


Figure 25. *Combination dual firing system.*

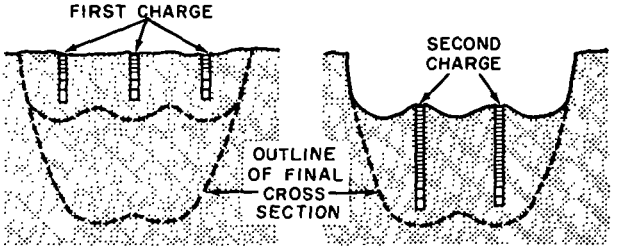


Figure 26. *Method of loading a deep, narrow ditch.*

(4) The cross-section method of loading to clean and widen ditches is explained grophicolly in figure 29.

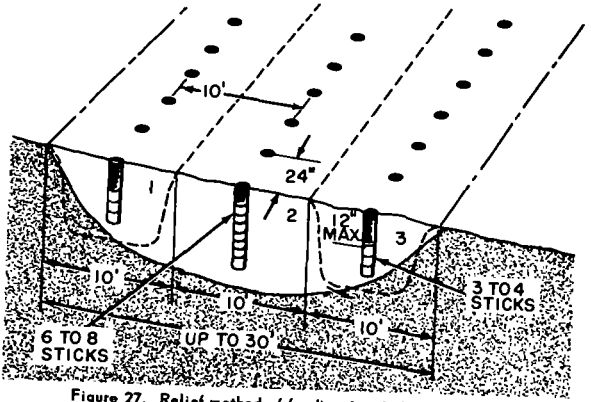


Figure 27. Relief method of fooding for shollow ditches.

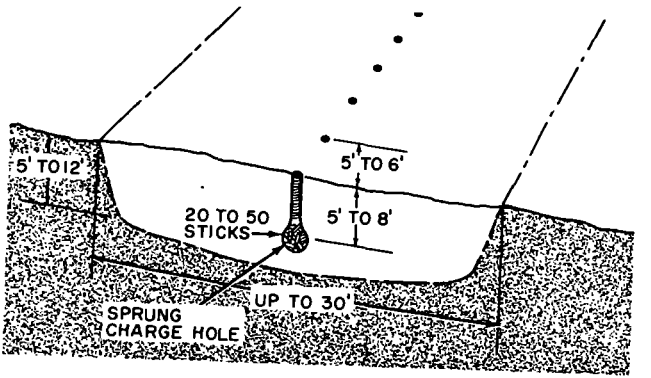


Figure 28. Post-hole method of looding for shollow ditches in mud.

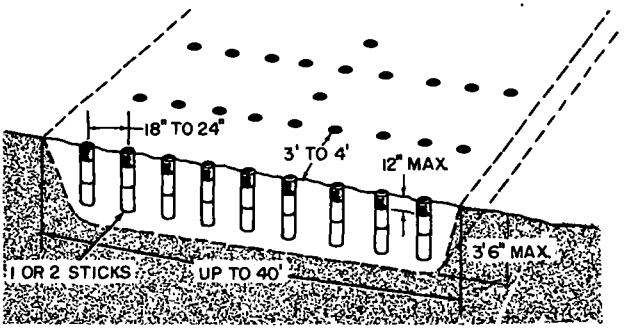


Figure 29. Cross-section method of loading to clean and widen ditches.

21. BLASTING TREES AND STUMPS

a. Size of Charge Required. The size of the charge required varies with the size, variety, and age of the tree or stump, and with the soil conditions. The rule of thumb (22 below) shows how the size of charge varies with the size and age, using 50-percent dynamite. To remove stumps properly, test shots are required.

b. Drilling Holes for Charge. In drilling holes for the charge, follow illustrations in figure 30.

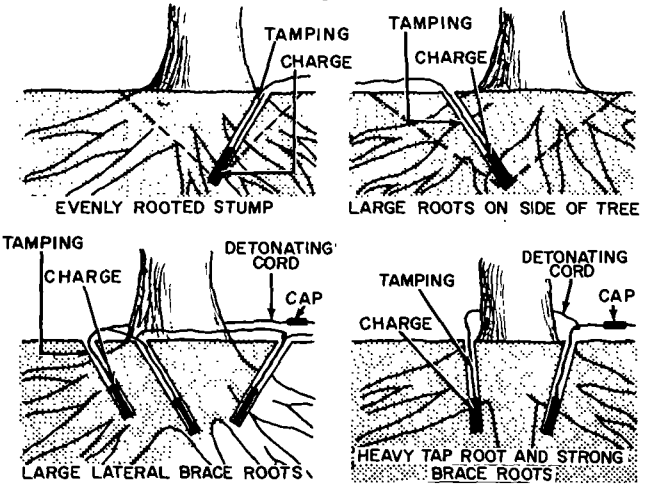
22. BLASTING BOULDERS

a. Size of Charge. See table 12.

b. Methods of Blasting. See figure 31.

Table 12. Charges for Blasting Boulders

Boulder diameter, ft	Lbs of TNT required		
	Blockholing	Snakeholing	Mudcapping
1½	1/8	½	1
2	1/8	½	1½
3	¼	¾	2
4	3/8	2	3½
5	1/2	3	6



Rules of Thumb. Use dynamite as follows:

(1) For dead stumps -- 1 pound per foot of diameter.

(2) For live stumps -- 2 pounds per foot of diameter.

(3) For standing timber -- add 50 percent for standing timber.

Figure 30. Stump-blasting methods for various root structures.

23. BOOBYTRAPS.

A boobytrap is an explosive charge which is exploded by an unsuspecting person when he disturbs an apparently harmless object or performs a presumably safe act. Different mechanical devices permit many variations which cause the firing device to function. Boobytrap areas are marked as shown in figure 40.

a. Direct Pressure. Direct pressure is the most commonly used method (fig. 32). Pressure of foot, wheel, or track operates the mechanisms.

b. Pull. Pull is used to initiate action. It may result from the movement of some concealed object such as a thin wire attached to the firing device (fig. 32).

c. Pressure Release. Release of pressure is an effective way to initiate action under many conditions. This method is used where enemy souvenirs are used as bait (fig. 32).

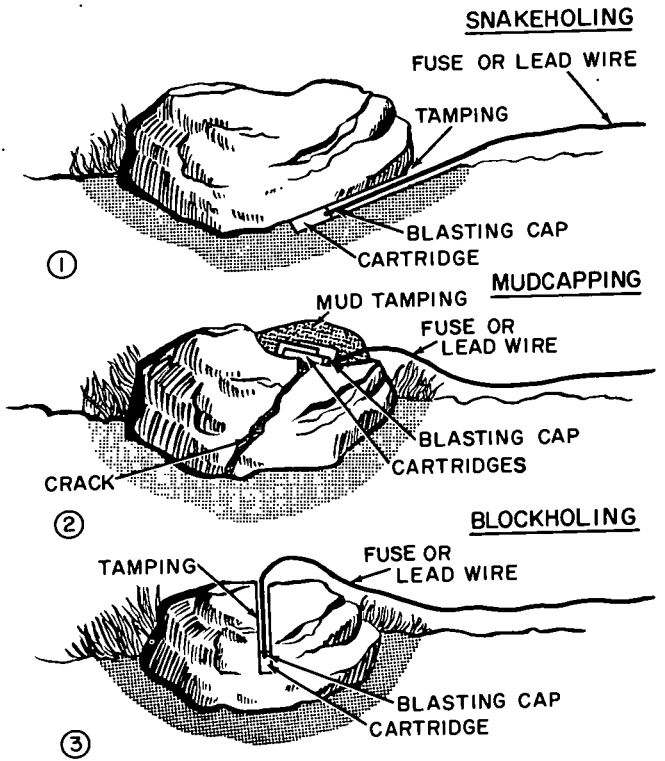


Figure 31. Methods of blasting boulders.

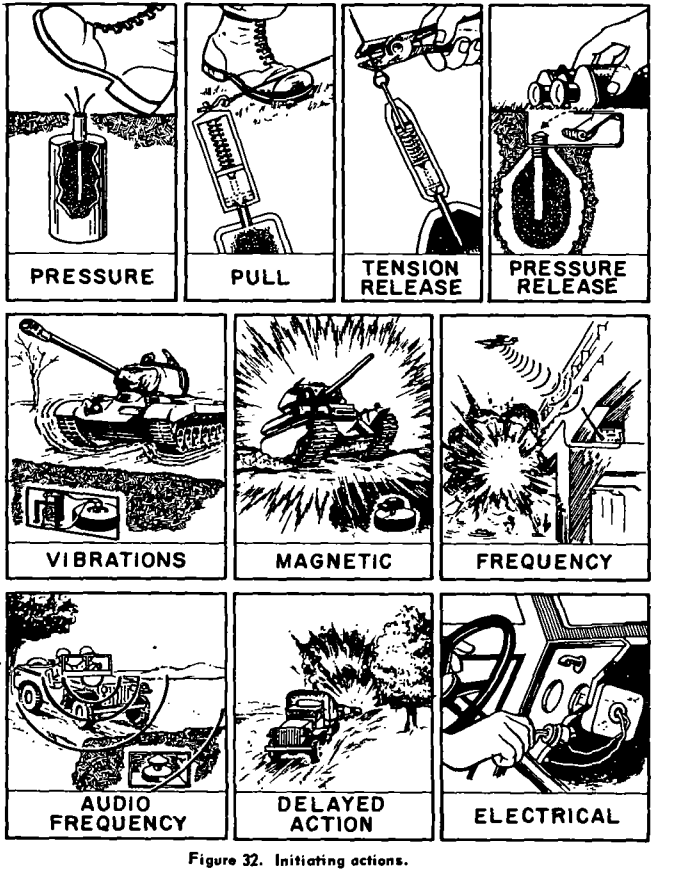


Figure 32. Initiating actions.

d. *Tension Release.* Release of tension is used when boobytraps are located among wires. Examples are found in barbed wire entanglements, or loose communication wires, where an enemy may use wirecutters (fig. 32).

e. Electrical Means. Electrical energy is used, where initiating action closes an electric circuit and fires an electric cap (fig. 32). Current is provided by battery.

f. Percussion. Percussion is widely used. The release of a compressed spring transmits energy through a striker (or firing pin) to a primer.

g. Chemical Action. Chemical action is used within a firing device. Here chemicals either damage and release firing components held in safe positions by some contrivance such as wires, or initiate ignition in another chemical compound. Delays are introduced whenever time is required for chemical action.

CHAPTER 3

LAND MINE WARFARE

Section I. Minefield Instollotion

24. PLATOON ORGANIZATION

The organization of the plataan as the basic unit for installing a standard pattern minefield is presented in table 13.

Table 13. Plotoon Orgonizotion to Install Minefield

Personnel	Officer	NCO	EM	Equipment
Supervisory personnel	1	1	- - - - - - -	Officer: Map, lensatic compass, notebaak, and minefield recard farms NCO: Map, notebaak, and lensatic compass
Sitting party	- - - -	1	3	Stakes ar pickets, sledges, hammers, tracing tape an reels, and nails ta peg tape
Marking party	- - - -	1	2	Barbed wire an reels, marking signs, lane signs, wire cutters, glaves, sledges
Recarding party	- - - -	1	2	Sketching equipment, lensatic compass, minefield recard farms, map
1st laying party	- - - -	1	6 ta 8	Natebaak far squad leader, picks, shovels, pickets, and sandbags
2d laying party	- - - -	1	6 ta 8	- da -
3d laying party	- - - -	1	6 ta 8	- do -
TOTAL	1	7	25 to 31	

NOTE: Under CBR warfare canditians, personnel engaged in laying taxic chemical mines require pratective clathing ta include impregnated boots. Each individual will wear the pratective mask and pratective glaves. Decantamination and first aid equipment shauld alsa be an hand.

25. TYPES OF MINES

a. **Live Mines.**

(1) Antitonk Mines. The antitonk (AT) mines ore listed and described in table 14.

(2) Antipersonnel Mines. The necessary dato for antipersonnel (AP) mines ore listed in toble 14.

b. **Training Mines.** Troining mines ore pointed blue. In this category there are two types:

(1) The practice mine (blue) is o replico of a live mine which emits a puff of smoke and makes a noise to simulate detonation, but it does not explode.

(2) The inert mine (block) is o replico which does not explode or make a noise. A proctice fuze should never be used in an inert mine.

26. MINEFIELDS

a. **Siting.** The proper procedure in loying minefields is given in toble 15.

b. **Factors Influencing Siting.** In the siting of minefields the following foctors must be considered:

(1) Overall plon of operation

(2) Terrain

(3) Locotion of other obstocles

(4) Likely ovenues of enemy opproach

(5) Possibility of later expansion of the field

(6) Must be more hozordous for the enemy to breach than to flank

(7) Should compel chonneling of an ottocking force into o smoll oreo covered by mossed fires

(8) On lorge scale, site in potterns so that penetrotion of the foremost field will be contoined by subsequent fields

(9) Enemy capabilities in armor and infantry, in breeching methods, and in horassing or interfering with mine loying

(10) Availobility of mines ond restrictions on use of certain types

(11) Troops available for mine laying, and their experience

c. **Lones ond Gaps.**

(1) Site the lones and gaps so that the unit protecting the field, and odjocent units, may corry out operotionol plans such as potrolling, ottocking, ond counterottocking. The tacticol commonder gives the generol location of lones and gaps to the commander of the loying unit. Skillful siting of the lones and gops will prevent the enemy from eosily determining their location.

AP mines

Table 14 Continued

(A) Mine type & model	(C) Mine weight (lbs) (total/ explosive)	(D) Weapon's Effect	Illustrations	(F) Emplacement Capability and Limitations
1. M2 Metallic, bounding, frag	5/0 4	Fragmentation penetration 360° danger area @ 10 mtr radius w/40% probability that anyone in the area will be a casualty		Must be manually emplaced in holes.
2 M3 Metallic, fixed frag	9 6/0.9	-do-		Normally used in booby trapping - can be tied to trees or posts and trip wired to cover trails, etc
3. M14 Non-metallic, blast.	0.25/0 008	Blast; injures the foot of the man who steps on it, blows a tire of wheeled vehicle		Must be emplaced by hand, buried flush w/surface & stoked in place. Slip-on collars of wire or cardboard can be improvised in the field to give the mine a "scatter" capability.
4 M16 Metallic bounding, frag	8/1	Fragmentation penetration 360° danger area @ 15 mtr radius w/50% probability that anyone in the area will be a casualty.		Must be manually emplaced in holes
5 M18 Metallic, fixed, shropnel (claymore)	2 5/0 8	Shropnel penetration 45° danger area @ 30 mtr in a zone 30 mtrs wide and 2 mtr high w/95% probability that anyone in the zone will be a casualty		Must be manually emplaced, either on a tripod above ground or tied to a tree, post, etc Mine is aimed down a defile or other avenue of probable enemy approach Back-blast from the mine is dangerous to 10 mtrs to rear & sides of mine
6 M23 Metallic chemical	23/0 8-HE/11 5VX	With VX liquid filler, contaminates an area w/a 24 mtrs radius (1800 sq mtrs) w/a contaminates density which is lethal to personnel through 2 layers of combat clothing		With primary fuze only, mine can be emplaced either by hand or by the Dan Patch & Starm Petrel mine layers but can be actuated only by vehicles which tend to "smother" the contamination & greatly reduce the area of contamination. Must be manually emplaced & activator inserted in the side fuze well if the mine is to be rigged for personnel actuation or for controlled firing.

AT mines

Table 14. Mine Data

(A) Mine type & model	(C) Mine weight (lbs) (total/explosive)	(D) Weapon's Effect	Illustrations	(F) Emplacement Capability and Limitations	(G) Mine density
1. M6 Metallic AT	20/12	Blast; blows a wheel or breaks a track of vehicles.		Can be manually laid on the ground or buried in holes. Can be machine laid by the Dan Patch and Storm Petrel mechanical mine planters. Activating is not possible when machine laid.	3
2. M7 Metallic AV	5/3.5	Blast, blows a tire of wheeled vehicle, breaks track of light tracked vehicles.		Must be manually laid - either on ground or buried. For use against heavy tanks, 5 mines must be *laid together* to be effective.	3.
3. M15 Metallic AT	31/21	Blast, blows wheel & breaks track of any vehicle.		As for M6, also, when the M15 is manually buried, the holes must be sloped outward at a 45° angle, the mine buried flush with the top of the ground and dirt mounded over the mine about 1½" high in order to insure detonation by a vehicle. With the *count fuze*, mine can be set for detonation on the first, second, or any other number of actuations up to at least 5. This fuze will make *the mine practically immune to breaching* by mechanical or explosive breaching devices.	3 -de-
4. M19 Non-Metallic AT	28/21	As for M15		Must be manually laid either on the ground or buried flush with 1½" dirt mound in holes sloped outward at a 45° angle. Slight modification to both the Dan Patch & Storm Petrel are required before they can plant this mine.	3
5. M21 Metallic AT	18.75/11	Blast & armor piercing penetration. Blows a wheel and breaks a track if detonated there or will penetrate the belly of vehicles to kill or injure the crew.		Must be manually laid in holes dug by an earth auger (*manually dug holes are too uneven and irregular* to permit the snug, even fit required to keep the mine from tipping over when a vehicle hits the tilt rod). Can be laid on end as an offroad mine to "cover" roads & defiles. In this position the black powder charge must be removed and an electrical firing system inserted for control firing by a concealed observer; or a trip wire attached to a firing device adapted to the fuze well can be rigged for vehicle actuation.	1.5

AP mines

Table 14 Continued

(A) Mine type & model	(C) Mine weight (lbs) (total/ explosive)	(D) Weapon's Effect	Illustrations	(F) Emplacement Capability and Limitations
7 M25	22	Shaped charge, directional type, capable of injuring foot of person, will penetrate 12-ply auto tire and tube		Manually emplaced with pressure on shoulders of mine to force it into ground Insert charge into body recess until safety clip rests on shoulders of mine.

Table 15 Consolidated Minefield Data

Field Requirements

Type of field	Required authority	Tactical employment	Type of mine	Marking required	Removal required
Protective	Battle Group and Battalion, Commander or higher May not be delegated to lower than company commanders	Close-in protection and warning to small units in the battle position, in a rear area, or on an isolated mission such as outposts, or defense of roadblocks. A protective minefield is normally laid on short notice for a limited time	All mines must be readily detectable. No boobytraps AT, Apers and improvised mines may be used Trip flares should also be used	Marked and/or guards posted as required to protect friendly troops	Yes, removal required by laying unit unless relieving unit commander specifically requests them to be left in place. Certificate of transfer sent to lowest commander having command over both units involved
Defensive	Battle Group and Battalion, Commander or higher May not be delegated to lower than company commanders	Installed in accordance with the divisional plan to strengthen the defensive position in the front, rear, and on the flanks, to disorganize enemy attacks, and to canalize enemy movements They are not laid on short notice	All types of AT and Apers mines. If feasible, at least 5% of AT mines should be boobytrapped. Trip flares should be included	As required to protect friendly troops. Normally the standard marking fence w/markers is used	No, if responsibility is transferred, certificate will be completed as for a protective minefield
Barrier	Division Commander or higher Can not be delegated	To cover intervals between strongly defended localities to deflect the enemy into chosen killing grounds, and to protect flanks and rear of positions against envelopment May be planned and installed prior to outbreak of hostilities, when it appears that war is imminent and that a prolonged defense is necessary	All types of AT and Apers mines, to include toxic chemical mines if authorized and appropriate to the purpose of the field If feasible, at least 20% of AT mines should be boobytrapped Trip flares should be included	As required to protect friendly troops and civilians Normally the standard marking fence with markers is used.	No.

Table 15. Continued

Reports and Records—Continued

Type of field	Reports required	Records required	Density	Pattern	Remarks
Defensive	1. Intention to lay. 2 Initiation of laying. 3. Completion of laying. 4. Progress (if large field). 5. Report of change Forward completion report to Army Hq	Standard form with at least minimum information Forward to at least Div Hq A record of change is required if field is altered	Initially 1 AT & 2 or 3 Apers and 1–4–8 on completion	Normally the standard pattern will be used.	1 Min depth of 100 yds, 300–500 yds is desirable. 2 Must be covered with fire
Barrier	1 Intention to lay. 2 Initiation of laying 3. Progress of laying 4 Completion of laying. 5 Change of field Completion report to Army Hq.	Standard form with at least minimum information. Forward to Army Hq. Record of change is required.	Minimum required density: 3 AT, 4 Irag Apers and 8 Blast Apers mines per yd of front.	Standard, nonstandard patterns and scattered mining is authorized.	1 Air and ground observation is required 2 Mobile fire units usually used to defend field
Nuisance	1 Intention to lay 2 Initiation of laying. 3. Progress (if large field). 4. Completion of laying. 5 Change of field. Completion report to Army Hq	Standard form. Forward to Army Hq.	None specified	None specified.	1 Abandoned fields became nuisance fields 2 May or may not be covered by fire. 3 A booby trapped area is considered a nuisance minefield
Phony	SAME AS FOR THE TYPE FIELD SIMULATED				1. Planning & coordination for laying & fire coverage must be done with same care as for type field being simulated.
Enemy	Location (include apparent boundaries and known bypasses) Forward to Army Hq by unit locating field.	Standard record form with as much information as is available Forward to Army Hq by unit discovering field.			

Table 15 Continued

Field Requirements—Continued

Type of field	Required authority	Tactical employment	Type of mine	Marking required	Removal required
Nuisance	Army Commander or higher May be delegated to Task Force Combat Command or Division.	To delay, disorganize and lower morale of advancing enemy; to hinder his use of an area or route. Particularly effective in retrograde movement, denial operations and during evacuation	All types of AT and Apers mines, boobytraps and dirty trick devices, to include toxic chemical mines if authorized and appropriate to the purpose of the field. If time permits all AT mines should be boobytrapped	None, unless initially protect friendly troops	No.
Phony	The Commander who has the authority to *install the type* minefield simulated.	To deceive the enemy into thinking that an area contains mines. Used in conjunction with live minefields to supplement or extend them; will seldom be used alone. Used to camouflage gaps in live fields; these gaps may be used as counterattack routes	Normally does not contain live mines. A few mines may be installed to increase deception.	Same as for type field simulated.	Live mines (if used).
Enemy (any minefield that the enemy laid or has an opportunity to influence the disposition of mines therein).			All types of mines, special fuzes, and boobytraps.	Marked and/or guards posted to protect friendly troops, by first unit discovering the field.	No.

Reports and Records

Type of field	Reports required	Records required	Density	Pattern	Remarks
Protective	1 Intention to lay 2 Initiation of laying 3 Completion of laying. 4. Report of change, if any 5. Report of removal. Forward all reports to Div Hq or equivalent Hq.	Standard form with at least minimum information. Exception. urgency of tactical situation may sometimes preclude recording at time of laying. Forward record if ordered.	None specified.	None specified.	1. Must be covered by fire. 2 Several men should know exact location of each mine.

(2) Change the location of lanes and gaps frequently to prevent detection and subsequent ambush of friendly patrols. Tactical commanders must always be consulted regarding future locations of lanes and gaps.

27. STANDARD PATTERN

a. Pattern. The standard pattern is illustrated in figures 33 and 34, and statistical details are given in table 15.

b. Clusters. The mine cluster (fig. 35) is the basic unit of the standard pattern minefield. A cluster may contain from one to five mines. Two rows of clusters make up a minestrip, as shown in figure 34.

c. Numbering. The clusters in each strip are numbered from the right end of the strip when facing the enemy (fig. 36). Cluster number 1 is the first cluster on the right when looking down the strip.

d. Tripwires. If tripwires are used, they are placed on antipersonnel mines in the enemy side of strip centerline row with not more than one tripwire-activated mine to a cluster, and no closer than every third cluster (fig. 37).

e. Arrangement. The strips are not always parallel; a center line may have as many turning points as desired (fig. 38).

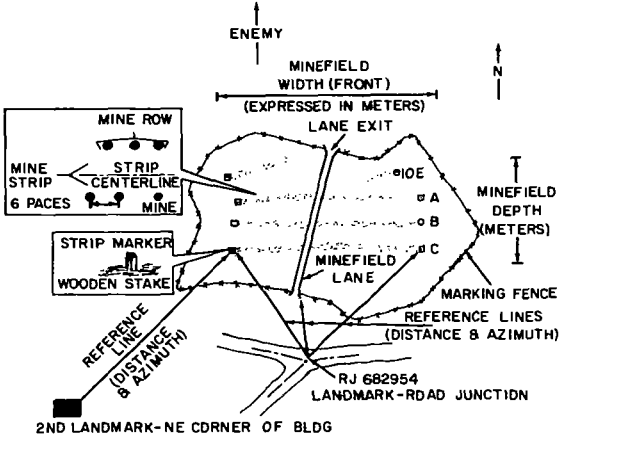
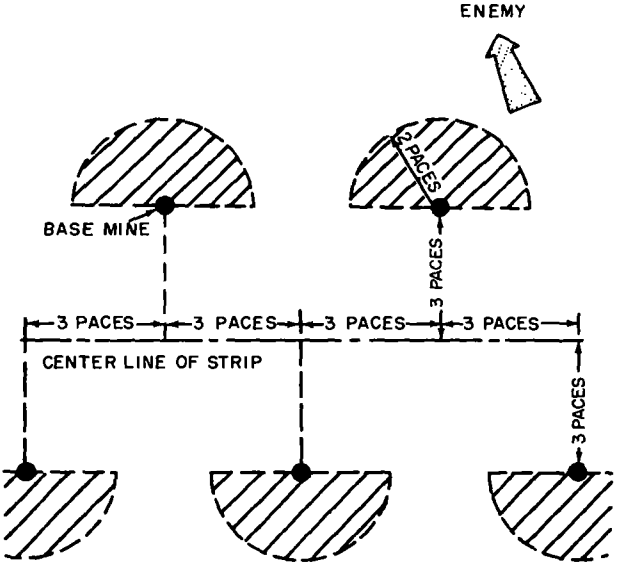


Figure 33. Standard minefield, fenced, marked, and referenced.



CLUSTERS ARE LAID ON BOTH SIDES OF STRIP ℄

THE CENTRAL MINE IN EACH CLUSTER MAY
BE EITHER ANTITANK OR ANTIPERSONNEL FRAGMENTATION

ADDITIONAL MINES, ANTIPERSONNEL ONLY, ARE PLACED
WITHIN EACH CLUSTER (SHADED AREA) IF DESIRED

Figure 34. Mine strip.

28. MINEFIELD MARKING

a. Rear Area Minefields. Completely fence a rear-area minefield with two strands of barbed wire at the time of laying (fig. 39). As figure 33 depicts, the fence does

not follow the oxact boundary of the field, but is placed whore it does not indicato the boundary. It is not placod loss that 20 paces from the nearost mino. Standard markers (fig. 40) aro hung on tho upper strand so that tho word "minos," ond, in tho case of a chomical agont field, the word "gas" faces away from the field. Lanos aro marked as shown in figure 41.

b. Forward Area Minefiolds. Mark forward aroa minefiolds the same as just doscribod in o, with theso excoptions:

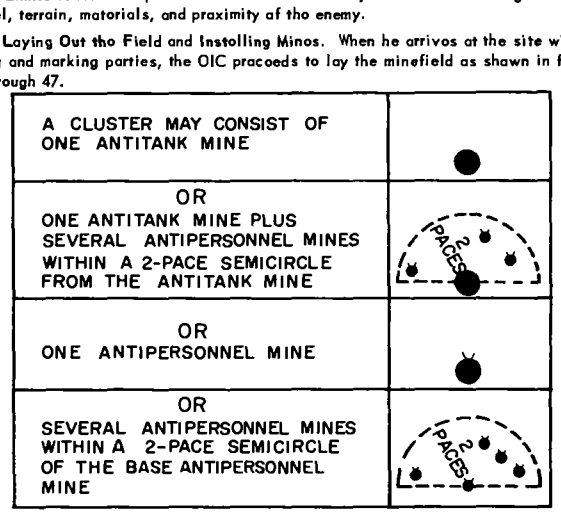
(1) Minefields forward of tho FEBA are somotimes fencod only on tho friendly sido, or on the friondly side and flanks.

(2) Lanes in forward aroas aro marked inconspicuously by placing wire, tape, or closely spaced objects an tho ground on oach sido of tho lano, with the lane entranco identifiod by markers such as pickots markod with tapo or pilos of stonos, and tho liko. Do not mark lane oxits on onomy side. Fonc-ing, marking, and camouflaging of minofields must be carofully maintained.

29. INSTALLATION PROCEDURE

a. Limitations. Tho proceduro describod here may be variod according to tho por-sonnel, terrain, matorials, and praximity af tho enemy.

b. Laying Out tho Field and Instolling Minos. When he arrivos at the site with his siting and marking parties, the OIC pracoeds to lay the minefield as shawn in figures 42 through 47.


A CLUSTER MAY CONSIST OF ONE ANTITANK MINE
OR
ONE ANTITANK MINE PLUS SEVERAL ANTIPERSONNEL MINES WITHIN A 2-PACE SEMICIRCLE FROM THE ANTITANK MINE
2 PACES
OR
ONE ANTIPERSONNEL MINE
OR
SEVERAL ANTIPERSONNEL MINES WITHIN A 2-PACE SEMICIRCLE OF THE BASE ANTIPERSONNEL MINE
2 PACES

Figuro 35. Mine clusters.

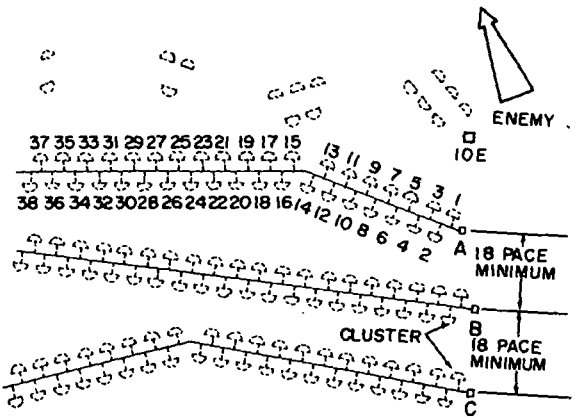


Figure 36. Method of numbering clusters in mine strips.

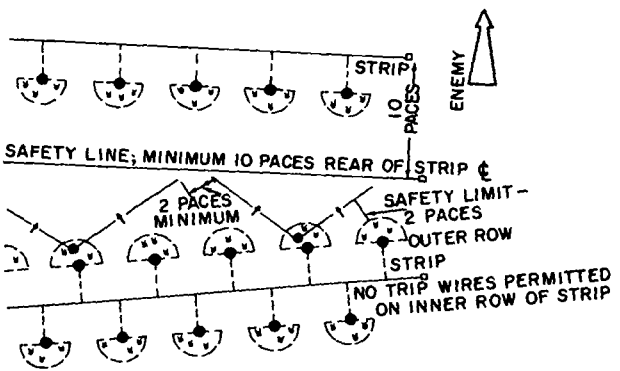

STRIP
10 PACES
ENEMY
SAFETY LINE; MINIMUM 10 PACES REAR OF STRIP ℄
2 PACES MINIMUM
SAFETY LIMIT — 2 PACES OUTER ROW
STRIP
NO TRIP WIRES PERMITTED ON INNER ROW OF STRIP

Figure 37. Use of trip-wires on front row of mine strip.

c. Use of Dozer-Mounted Scoop. This minefield scoop is used to dig holes for the emplacement of mines. It digs the holes only; personnel must plant, arm, and bury the mines. The scoop may be adjusted to fit any dozer blade. The tractor operator controls the digging rate and length of hole.

CLUSTER #3 IS LAST CLUSTER OF A STRIP SECTION

CLUSTER #4 IS FIRST CLUSTER OF A STRIP SECTION

THE LAST BASE MINE WILL NEVER BE LAID CLOSER THAN 3 PACES TO END OF A STRIP SECTION

THE FIRST MINE LAID ON A SECTION OF A STRIP WILL ALWAYS BE 3 PACES FROM THE TURNING POINT AND ON THE OPPOSITE SIDE OF STRIP CENTERLINE FROM PREVIOUS CLUSTER LOCATION

IF NECESSARY TO TURN ANGLES SHARPER THAN THOSE SHOWN, OMIT A CLUSTER TO ASSURE BASE MINES BEING 6 PACES APART, AND NO CLUSTER AREA CLOSER THAN 3 PACES FROM ANY CENTERLINE TAPE

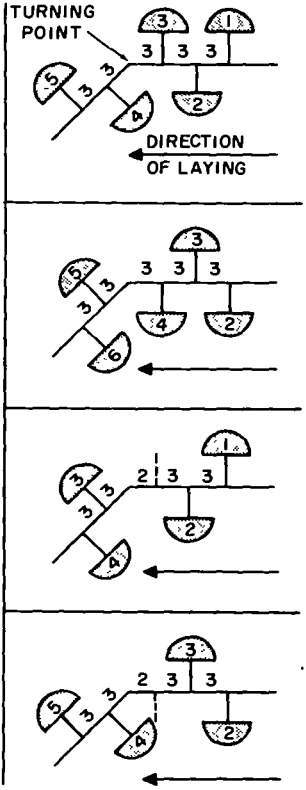


Figure 38. Turning points in a mine strip.

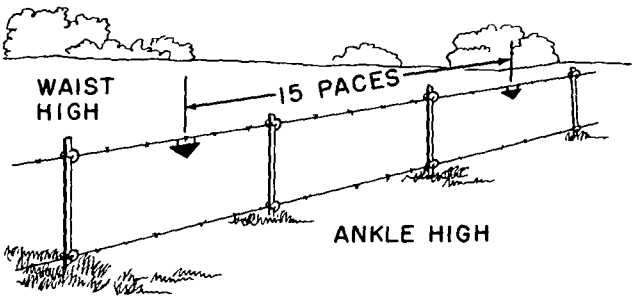


Figure 39. Standard minefield marking fence.

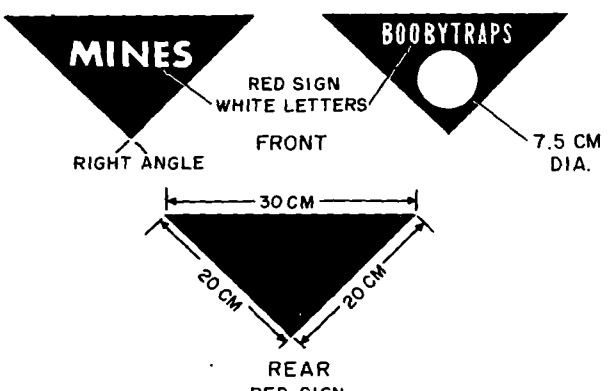


Figure 40. Standard marking signs.

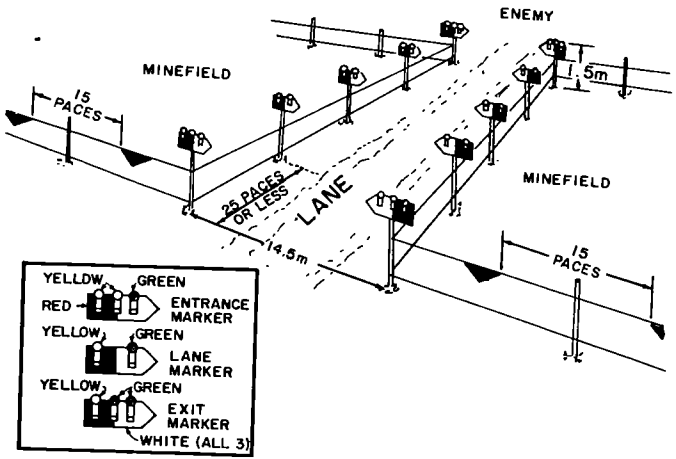


Figure 41. Standard minefield lane marking in rear area.

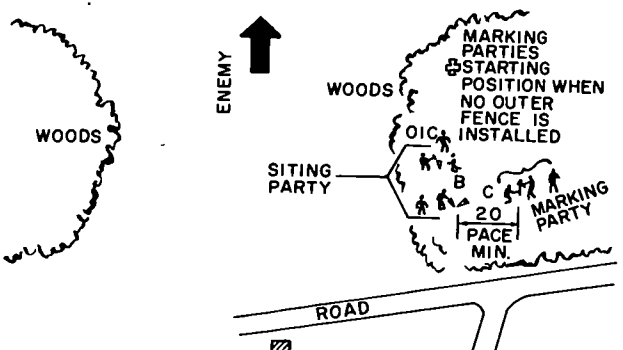


Figure 42. Initial steps in laying minefield.

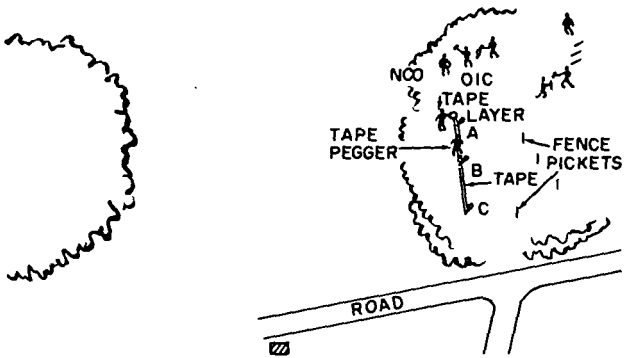


Figure 43. Establishing the right-hand boundary stakes of a minefield.

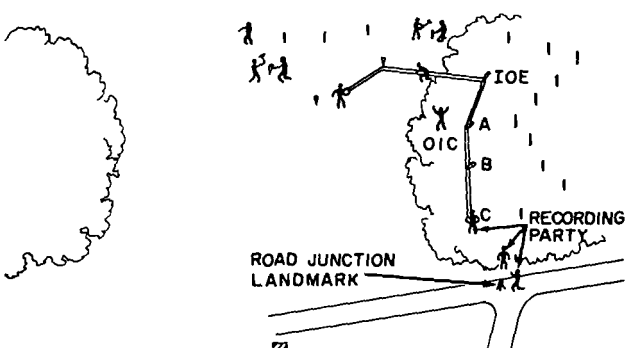


Figure 44. Laying out the IOE strip.

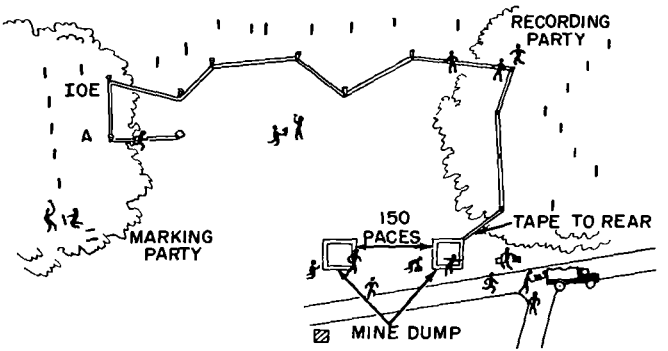


Figure 45. Laying out strip A and establishing mine dumps.

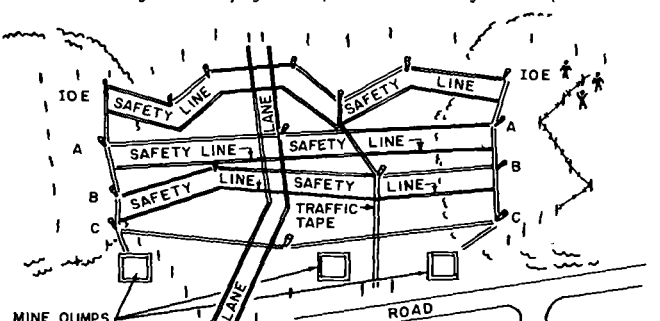


Figure 46. Minefield completely taped, including safety lines, and traffic and safety lanes.

d. Logistical and Planning Data. See table 16.

e. Material and Manpower Requirements. See table 17.

f. Camouflage. The principles expressed in FM 5-20 apply to all phases of mechanical mine planting, including camouflage of the equipment and of the minefield.

Table 16. Logistical and Planning Data (per 100 meters of minefield front)

Type mine-field	Density	AT, M15	AP, Frag, M16	AP, Blast, M14	Totol	Mine weight, tons per 100 m.		Time required per 100 m.		2½-ton trucks per 100 m. (mines crated)	Truck companies, 2½-ton (mines crated)
						Crtd	Uncrtd	Man-hours	Com-pony days		
Defensive	1-2-4	153	306	612	1071	5.06	3.7	230	.230	2	.053
Defensive	1-4-8	153	612	1224	1989	7.4	5	415	.415	3	.080
Defensive	2-4-8	291	612	1224	2127	10.8	7.2	445	.445	4	.105
Borrier	3-4-8	428	612	1224	2264	14.2	9.4	445	.445	5	.130
Protective	None	22	22	—	44	0.5	0.4	11	.011	1	.025

Toble based on the following:

1. Total mines includes mines in strips plus IOE and 10 percent safety factor.
2. Cluster composition in IOE - 1-2-2.
3. Mine weights based on M15, M16, and M14 mines.
4. Time required based on o laying rate of mines per hour per man in on A/T and A/Pers field (these figures are subject to revision upon publicotion of CONARCT tests).

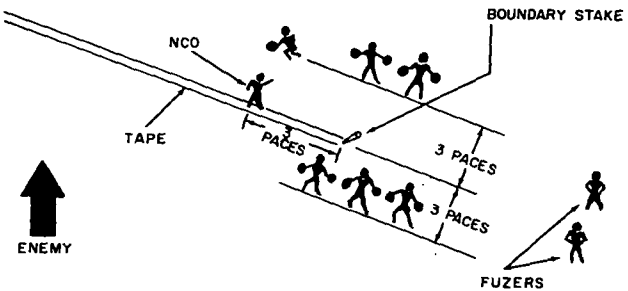


Figure 47. Laying mines on a section of a regular strip.

Mines should be buried or not, depending upon type of mine, terrain, mine-laying technique. When AT mines are planted by hand, they should be buried flush with, or slightly above, ground level. Regular mounds of earth over each mine, the distinctive appearance of the trace of the mechanical planter, and the tracks of vehicles furnish special problems. On bare soil drag a heavy chain or similar object. A method of burying and camouflaging mines is shown in figure 48.

g. Mechanical Mine Planting When Using "Dan Patch" Mine Layer.

(1) The mechanical planter is towed by a modified D7, D8, or similar crawler tractor. Supplementary equipment includes tractors, cranes, magazine supply vehicles (trucks or helicopters), and siting and marking devices.

(2) Personnel requirements are –

(a) Operators for supplementary equipment.

(b) One NCO (combat construction foreman) and 13 to 17 men for each mine handling unit.

(c) One NCO (combat construction foreman) to supervise each planter.

(d) One maintenance mechanic for each set of mine planting equipment.

(e) One minefield guide per planter, if needed.

Table f7. Minefield Material and Manpower Requirements

	Material	Average requirement per 100 meter of minefield trace					
		Antipersonnel	Antitank Minefield				
1		Minefield 0-4-8 (1)	Protective None (1)	Defensive 1-2-4 (1)	Defensive 1-4-8 (1)	Defensive 2-4-8 (f)	Barrier 3-4-8 (f)
	ANTITANK MINES						
2	Heavy Metallic						
3	Heavy Nonmetallic						
4	Total Antitank Mines			(See table 16)			
	ANTIPERSONNEL MINES						
5	Fragmentation						
6	Blast						
7	Total Antipersonnel Mines						
	FIRING DEVICES FOR MINE ACTIVATION						
8	Assorted	---	---	12	12	12	f37
	TRIP FLARES						
9	Parachute	20	10	18	18	f8	18
10	Candle	7	4	6	6	6	6
11	Total Flares	27	14	24	24	24	24
	BARBED WIRE (Marking Fence Only)						
12	400 yd reels			(See table f6)			
	PICKETS (Marking Fence Only)						
13	Long	94	---	93	93	93	93
f4	Short	f4	---	12	12	12	f2
	MANPOWER						
15	Man hours						
16	Company days			(See table 16)			

NOTES.

(1) Mine field density
1st number = number of AT mines per yd of front
2nd number = number of AP fragmentation mines per yd of front
3rd number = number of AP blast mines per yd of front

(2) Total mines include mines in strip plus f0E and 10 percent safety factor

(3) Cluster composition in f0E - 1-2-2.

(4) Mine weights based on M15, M16, and M14 mines

(5) Time required based on a laying rate of mines per hour per man in an AT and AP field

30. REPORTING AND RECORDING

a. Reports.

(1) Except for protective minefields, three reports are required for every minefield laid. First is the report of intention to lay, which is made as soon as it is decided to install the minefield. The second report is the initiation of laying and is made when the laying unit is ready to begin. Third is the report of the completion of laying. All reports are classified SECRET. Protective minefields require only the first and third reports. The maximum length of a minefield to be recorded on one form DA1355 is 550 meters.

(2) In addition, there is the written report of transfer mode to the relieving commander by the commander of the unit responsible for the field when the transfer of responsibility is effected.

(3) Also, there is a report mode to the next higher commander immediately when friendly mines are removed.

(4) Lastly, when any changes are made in a friendly minefield, a report is sent by the commander responsible for the mine field to the headquarters which ordered the mines laid.

(5) Progress reports are initiated according to unit SOP.

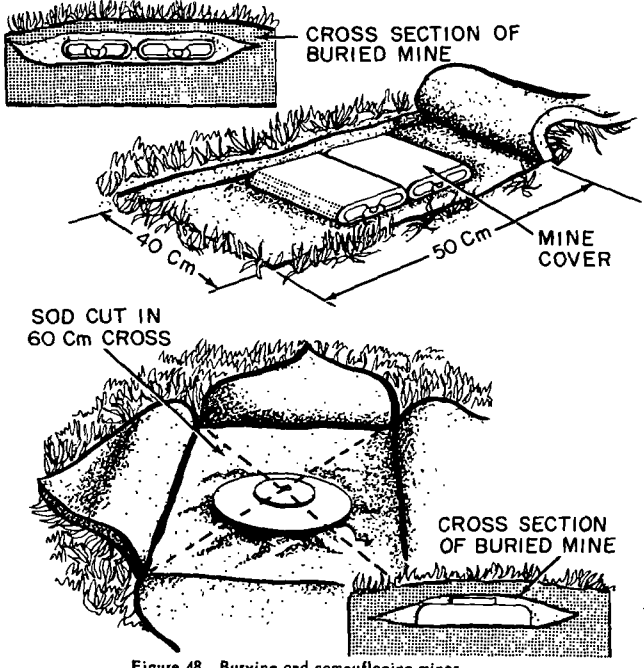


Figure 48. Burying and camouflaging mines.

SECRET (WHEN COMPLETED)

SHEET 1 OF 1

CO B, 15TH ENGR COMBAT BN — LATING UNIT
30 MAR 1200 HRS — COMPLETION DATE AND TIME
THOMAS JONES 2ND LT ENGRS — OFFICER IN CHARGE (NAME, RANK, SERIAL NO.)
12 A-DE — MINEFIELD NUMBER

LANDMARKS

NO	COORDINATES	DESCRIPTION
1	342677	RJ
2	343676	SW CORNER BUILDING
3		
4		

INTERMEDIATE MARKERS

NO	DESCRIPTION
1	THREE STEEL PICKETS WRAPPED W/WIRE
2	
3	
4	

DESCRIPTION OF BOUNDARY FENCE: STANDARD

NO. OF STAKES: 9 — DESCRIPTION OF STAKE MARKER: STAKES DRIVEN FLUSH

MAP SHEET: TALBOTVILLE
SHEET NO: 5561 — SCALE: 1:50000
RECORDED: John C. Jones, 2Lt

LANES

GENERAL INFORMATION

NO.	WIDTH	SIDE MARKED	MINES IN LANE: TYPE AT/AP	TYPE NO	TYPE NO
1	8 M	Field Wire Pegged Down on ℄	4		
2					
3					

NOTES

LANE ENTRANCE MARKED BY 3 TURNS OF TRACING TAPE WRAPPED AROUND BOTTOM OF FENCE PICKET

LANE EXIT MARKED BY ONE WOODEN STAKE DRIVEN FLUSH ALONGSIDE FENCE PICKET

4 M-15 MINES LAID IN LANE WHERE IT CROSSES STRIP A

SIGNATURE: Thomas Jones 2nd Lt

ANTI-TANK MINES

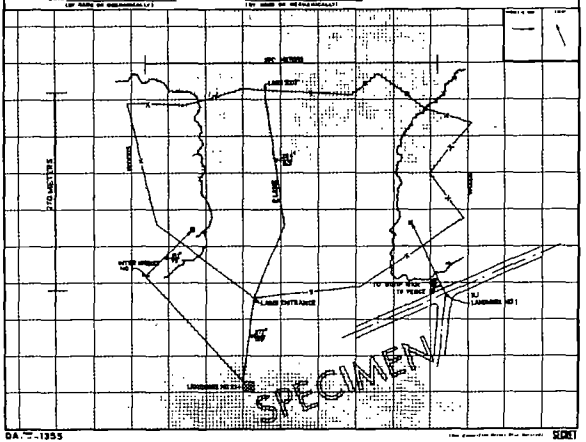
STRIP	TYPE M-15 NO	TYPE NO	TYPE NO	TYPE NO	TOTAL M-15 NO	GRAND TOTAL NO
TOTAL PLACED ONLY	318				313	36
105	19				17	0
A						
B						
C						
D						
E						
F						

LAID HAND (BY HAND OR MECHANICALLY)

ANTIPERSONNEL MINES

STRIP	TYPE M-16 NO	TYPE M26 NO	TYPE NO	TYPE NO	TOTAL M-16 NO
TOTAL PLACED ONLY	826	313			839
105	0	51			61
A					
B					
C					
D					
E					
F					

LAID HAND (BY HAND OR MECHANICALLY)



DA FORM 1355

SECRET

Figure 49. Minefield record with minimum information.

SECRET (WHEN COMPLETED)

SHEET 1 OF 1

CO B 15th Engr Combat Bn — LAYING UNIT
301400 June 53 — COMPLETION DATE AND TIME
Thomas Jones 2nd Lt 046820 — OFFICER IN CHARGE: RANK, NAME, SERIAL NO.
15-B 52 — MINEFIELD NUMBER

LAROMARKS

NO	COORDINATES	DESCRIPTION
1	942677	RP
2	943674	SW Corner Building
3		
4		

INTERMEDIATE MARKERS

NO	DESCRIPTION
1	Frame Steel Pickets Wrapped W/wire
2	
3	
4	

DESCRIPTION OF BOUNDARY FENCE: Standard

NO. OF STRIPS: 3 — DESCRIPTION OF STRIP MARKERS: Stakes Driven Flush

LANES

NO	GENERAL INFORMATION: WIDTH	GENERAL INFORMATION: NON MARKED	MINES (IF LAID): TYPE M/12 NO	TYPE NO	TYPE NO
1	6m	Field Wire Pegged Down on E	4		
2					
3					

MAP SHEET: Talbotville
SHEET NO: 5361 — SCALE: 1 : 25000
RECORDED: John E Jones Jr

NOTES

LANE ENTRANCE marked by 3 turns of tracing tape wrapped around bottom of fence picket

LANE EXIT marked by one wooden stake driven flush alongside fence picket

4 M-15 mines laid in lane where it crosses strip A

SIGNATURE: Thomas Jones 2nd Lt

ANTI-TANK MINES

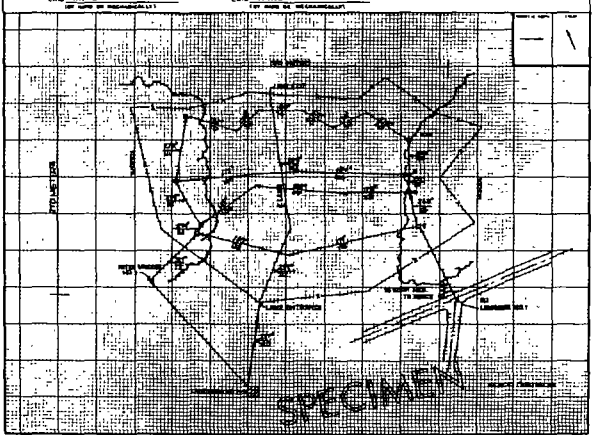
STRIP	LANE	TYPE M-15 NO	TYPE NO	TYPE NO	TYPE NO	TOTAL NO. MINES LAID NO	NUMBER PRIMED NO
TOTAL ALONG AXIS		313				313	34
	105	17				17	0
A		105				105	11
B		106				106	19
C		102				102	10
D							
E							
F							

LAID: Hand (NOT MORE THAN MECHANICALLY)

ANTIPERSONNEL MINES

STRIP	LANE	TYPE M/16 NO	TYPE M/14 NO	TYPE NO	TYPE NO	TOTAL NO. MINES LAID NO
TOTAL ALONG AXIS		626	313			939
	105	0	51			51
A		210	105			315
B		212	106			318
C		204	102			306
D						
E						
F						

LAID: Hand (NOT MORE THAN MECHANICALLY)



DA FORM 1355

SECRET

Figure 50. Minefield record with maximum information.

Table 18. Logistical Mine Data Table

Note: Figures in parenthases indicate maximum load within 100 percent overhead capability and/or maximum volume of cargo space

Mine packaging data											
Mine model & type	Weight per mine, lb.	No. of mines, etc., per crate	Weight per crate, lb.	Crate dimensions, in			M-35 2½-ton cargo truck (cargo space: 147 by 88 by 60 in.)				
				Length	Width	Height	No. of crates	How carried	No. of types of crates	Total of mines	Total weight, tons
M7 AV	5 0	8, w/fuzes	56	19 25	11	8 25	90 (178)	Flat	2 (4)	720 (1,424)	2 52 (4 98)
		12, w/fuzes	71.5	23.5	11.75	9.5	70 (140)	Flat	2 (4)	840 (1,680)	2 5 (5)
M6 AT	20.0	Uncrated mines	13.13 in diam			3.25		Flat	4	250 (264)	2.5 (2.64)
		1, w/fuze & activator	31	13 5	13.5	3 75	162 (322)	On end (flat)	1 (6)	162 (322)	2.51 (4 99)
		2, w/fuze & activator	60	18 13	16	9.75	84 (160)	Flat	2 (4)	168 (320)	2.52 (4.8)
M15	30.0	Uncrated mines		13.13 in diam		5		Flat (flat, 11 on end)	3- (3)	166 (209)	2 49 (3 13)
		1, w/fuze & activator	49	18	15.13	7.5	103 (200)	Flat	3 (5)	103 (200)	2 53 (4 9)
M19 AT	28 0	2, w/fuzes & activator	80	16.25	10.5	16	63 (125)	On end (on side)	1 (3)	126 (250)	2.52 (5)
M21 AT	18 5	2, w/T-1200 fuzes	50 3	26 5	11	7.33	100 (198)	On end (flat)	1 (5)	200 (396)	2.51 (4 97)
M25 AT	0 22	96	30	18	12	8	170 (392)	Flat		16,320 (37,632)	2 51 (5 88)
M2 AP	5 0	6, w/fuzes & wire	50	15	10 25	9.5	100 (200)	Flat	2 (3)	600 (1,200)	2 5 (5)
M3 AP	9.6	6, w/fuzes & wire	72	18	8 75	9.5	70 (138)	Flat	2- (2-)	420 (828)	2.52 (4.96)
M14 AP	0.21	90	44	18.6	18	8.7	115 (224)	Flat		10,350 (20,160)	2.53 (4.90)
M16 AP	8.0	4, w/fuzes & wire	45	15 75	10 13	8 5	112 (222)	Flat	2 (4)	448 (888)	2 52 (4 99)
M18 AP	2 5	6(M68 kit)	33.1	20	11.5	9 75	151 (294)	Flat	4 (6)	905 (1,764)	2 49 (4.87)
		10 (M69 kit)	45	14.25	15	17.25	112 (162)	Flat	2- (3)	1,120 (1,620)	2.52 (3.64)

Table 18. Continued

Mine model & type	M-105 1½-ton trailer (cargo space: 133 by 87 by 71 in.)					M-47 2½-ton dump truck (cargo space: 108 by 70 by 15 in.) (Volume is determining factor)				
	No. of crates	How carried	No. of tiers of crates	Total no. of mines	Total weight tons	Determine no. of crates	Capacity how carried	No. of tiers of crates	Total no. mines	Total weight tons
M7 AV	56 (110)	Flat	2 (3)	448 (880)	1.56 (3.08)	72	On end	1	576	2.01
	41 (85)	Flat (on end)	2 (1)	492 (1,020)	1.46 (3.02)	63	On end	1	756	2.25
M6 AT	.	Flat (on edge)	3 (2)	150 (300)	1.5 (3)	. .	On edge	1	165	1.65
	96 (195)	Flat	2 (4)	96 (195)	1.48 (3.02)	140	On end	1	140	2.17
	50 (100)	Flat	2 (4–)	100 (200)	1.5 (3)	42	On end	1	84	1.26
M15	. . .	Flat (on edge)	3 (2)	100 (200)	1.5 (3)	.	On edge (or flat)	1 (3)	105	1.57
	51 (122)	Flat	2 (4)	61 (122)	1.49 (2.98)	56	On end	1	56	1.37
M19 AT	37 (75)	Flat	1–2	74 (150)	1.48 (3)	40	On end	1	80	1.6
M21 AT	59 (119)	Flat	2 (4–)	118 (238)	1.49 (2.99)	81	On end	1	162	2.03
M2 AP	60 (120)	Flat	1 (2)	360 (740)	1.5 (3)	70	On end (or flat)	1 (2)	420	1.75
M3 AP	41 (83)	Flat	1–(2–)	246 (498)	1.47 (2.98)	70	On end (or flat)	1–(2–)	420	2.52
M16 AP	66 (133)	Flat	1–(2–)	264 (532)	1.48 (2.99)	80	On end (or flat)	1 (2)	320	1.80
M18 AP	90 (181)	Flat	3–(5)	540 (1,086)	1.48 (2.99)	63	On end	1	378	1.04
	66 (133)	Flat	2 (3)	660 (1,330)	1.48 (2.99)	28	Flat	1	280	.48
M14 AP	68 (136)	Flat	3 (5)	6,120 (12,240)	1.49 (2.99)	48	On end	1	4,320	1.05
M23 cham	27 (54)	Flat	2–(3)	71 (142)	1.48 (2.97)	24	On end	1	72	1.32
	2 pallets	Flat	1	96	1.84	2 pallets	Flat	1	96	1.84
M48 Parachute Flare	73 (146)	Flat	2–(3–)	292 (584)	1.49 (2.98)	70	Flat	2	280	1.43

b. Records.

(1) The standard minefield record is a single printed sheet as shown in the samples in figures 49 and 50. A standard minefield record form is prepared by the commander of the laying unit, signed by him, and sent to next higher headquarters. It is classified SECRET. The number of copies prepared depends on the type of minefield and SOP. Normally one copy is forwarded to higher headquarters. The SOP should provide for dissemination of records up, down, and laterally. For this purpose, the record is photographically reproduced.

(2) When changes are made to a friendly minefield, a completely new record must be prepared on the standard form. It is marked REVISED.

(3) Booby-trapped areas are recorded as nuisance-type minefields.

31. MINE SYMBOLS

Type unknown		AT, activated	
Apers		AT, double or multiple	
AT		Booby-traps	

32. LOGISTICAL DATA

See table 18.

Section II. Enemy Minefields

33. RECONNAISSANCE

a. Types.

(1) Ground reconnaissance.
(2) Aerial reconnaissance.
(3) Reconnaissance by fire.
  (a) Artillery, mortar, or rocket.
  (b) Bombing.

b. Reconnaissance Patrol.

(1) A minefield reconnaissance patrol should normally comprise an experienced officer or senior NCO, four to six trained men, and a security element armed with light automatic weapons and grenades (fig. 51).

(2) Depending upon the patrol's mission and types of mines it may encounter, equipment may include compasses, wirecutters, probes, mine detectors, disarming implements (wires, safety pins, and the like), tape, and protective body armor. If secrecy is not essential, include prepared demolition charges, grapnels, light lines, and similar means for mine removal. Where toxic chemical mines may be encountered, take such equipment as protective clothing, first aid supplies, and decontamination equipment.

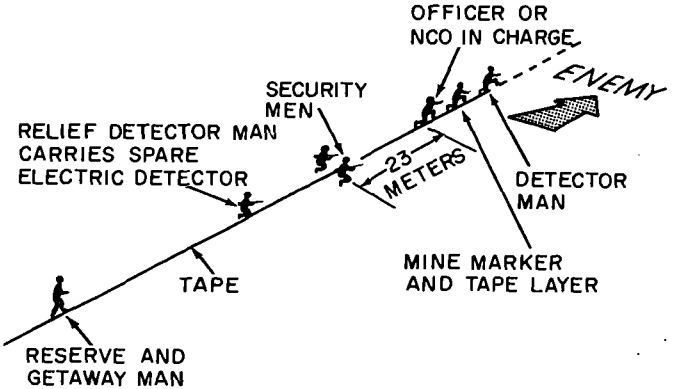


Figure 51. Minefield reconnaissance patrol.

(3) Where recannoissonce is preliminory to breaching, the patrol records infarmotion by o tope loid on the centerline af the path. Indicate location of tripwires ar types of mines by knots tied on tape os follaws:

Type	No. af knots
Apers mine	1
AT mine	2
Tripwire	3
New type mine	4
Toxic chemicol mine	5

34. REPORTING AND RECORDING

a. Reparting. Report ony knowledge or suspicion af the existence of an enemy minefield to the next higher commonder immediotely. Oral or written, this report is forworded ta division ond should include os much of the following information os is obtoinoble:

(1) Locotion and apporent baundories of the enemy minefield.
(2) Byposses around the field, if ony.
(3) Type and density of mines.
(4) Potterns.
(5) Enemy defenses, fortifications, fire coverage, ond observotion.

A unit encountering an enemy minefield erects temporary warning signs, pending installation of standard markings as prescribed in paragraph 28a for friendly rear area minefields. A report is made to the next higher headquarters whenever enemy mines are removed.

b. Recording. Use the standard U.S. minefield record form when preparing a record of an enemy field. This record contains the identity of the unit preparing it and is identified at the top by the words ENEMY MINEFIELD. Include a full description of the markings, a sketch or overlay showing location, and other information as outlined in paragraph 30b. Whenever additional information becomes available, another record is prepared and submitted to higher headquarters.

Section III. Breaching and Clearing Operations

35. MINE DETECTION METHODS

a. Visual. Visual search is an important method of locating mines. Experience with the mine habits of an enemy is often of great help in locating his mines. Likely locations are pointed out in FM 20-32.

b. Probing. In this method, the earth is penetrated with a sharp instrument such as a mine probe, a bayonet, or a stiff wire. Probing is the best way to locate buried nonmetallic mines, particularly the small antipersonnel type similar to the M14. The soldier moves on hands and knees with sleeves rolled up to locate tripwires and pressure prongs.

c. Electrical Detection. When used in connection with visual inspection and probing, mine detectors (metallic and nonmetallic) are effective aids in locating mines. Both types of detectors, small-metals or non-metallic, may give a signal when items other than mines are detected; experience in operating each type helps to determine the characteristics of the signal to be expected for each type of mine. For the soldier assigned to this task, it is an exacting job and he must constantly watch for booby-traps and tripwires. Twenty minutes at a time should be the maximum period for each soldier. Operation of these detecting sets is fully covered in TM 11-210 and TM 5-9541.

d. Truck-mounted Detector Set. This is a jeep-mounted detector set (AN/VRS-2). It has been designed to locate buried metallic AT and AP lead mines. This device may be set to stop all forward motion of the vehicle when a mine is detected. It can detect an M6 AT mine buried 20-1/2 inches below the surface. It can detect over a path 6 feet wide.

36. METHODS OF BREACHING MINEFIELDS

a. Hasty and Deliberate Methods. Breaching is the use of any means available to open a lane through a mined area for the passage of vehicles or personnel. It is either hasty or deliberate.

(1) Hasty breaching requires speed with a minimum of planning. Leading combat units must often clear a mine-free lane. Special mechanical or explosive devices, artillery or aerial bombardment, or specially trained teams accomplish this. See table 19.

(2) Deliberate breaching requires extensive planning, and is normally done by engineers or other trained personnel, supported by combined arms. Deliberate breaching is usually made in the following phases:

(a) Reconnaissance.

(b) Plans and preparations.

(c) Breaching and attack.

(d) Passage of forces.

Table 19. Minefield Breaching/Clearance

Average Time and Materiel Requirements

Method	Width of cleared lane (in meters)	Man-hours reqd per 100 meters	Remarks
Manual			
Location by probing . .	1 (footpath)	16 - 22	See note.
Removal by rope or explosives.	3.65 (vehicle lane)	38 - 44	See note.
Location by detector, assisted by probing . .	3.65 (vehicle lane)	27 - 33	See note.
Removal by rope or explosives.	23	220 - 247	See note
Explosive			
Demolition snakes, M3A1	2.75 - 3.65	0.80	Employment time only. 90 - 100 hrs reqd for assembly of M3A1.
Cable, antipersonnel, M1	1 (footpath)	3.5 - 4.5	Cable, antipersonnel, M1, is not effective against antitank mines.
Bangalore torpedo. . .	1 (footpath)	3.5 - 4.5	See note.

NOTE: Based upon average conditions of visibility and moderate enemy activity and normal U.S. countermeasures; i.e. screening of enemy observation and counter-battery fires against hostile artillery or other weapons covering the field.

b. Explosive Methods. The use of explosives is the easiest method of removing mines. A half-pound demolition block or a handful of plastic explosive, with a standard firing assembly, placed on top of a mine will detonate most mines. A detonating cord may connect a group of mines to fire them simultaneously (fig. 52). In flat or gently rolling terrain, the demolition snake is useful for deliberate breaching. This shaped-charge snake ("Diamond Lil") is 120 meters long, weighs about 10,000 pounds, and contains about 2880 pounds of explosive. It will clear mines over an area 100 meters long and 3.5 to 4.5 meters wide. It is pushed into a mined area by a tank. The tank then releases the snake, backs off, and detonates it by firing machinegun rounds into a cap on the near end of the snake. For hasty as well as deliberate breaching to provide foot lanes, the bangalore torpedo (fig. 53) and the rocket-propelled bangalore torpedo (fig. 54) are suitable. The rocket propulsion kit for the bangalore torpedo provides self-propulsion and remote detonation to a train of bangalore torpedoes. It will carry AP mines and barbed wire to provide a footpath ½ meter wide for troops. Both of these explosives are described in TM 9-1946 and TM 5-220.

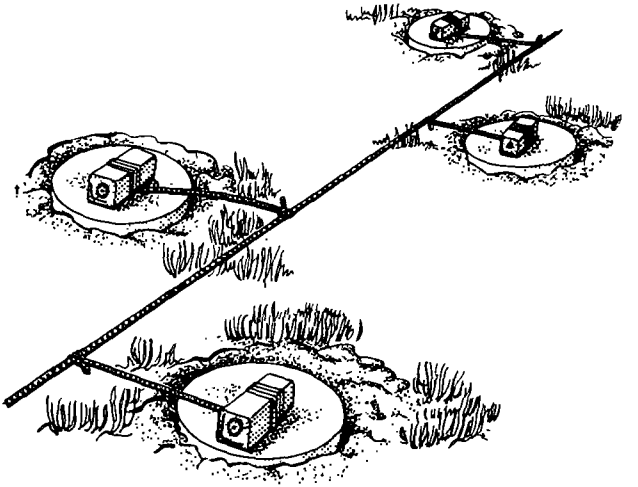


Figure 52. Mines prepared for destruction in place with explosive and detonating cord.

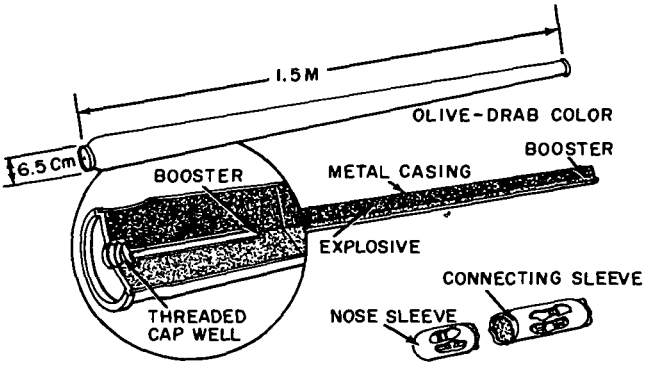


Figure 53. Bangalore torpedo.

c. Mechanical Methods. The term mechanical means refers to use of rollers, plows, flails, or similar devices, pushed by armored vehicles.

d. Platoon Organization and Equipment for Manual Breaching. Table 20 and figure 55 show the organization of this platoon and the operation of a breaching party, respectively.

37. METHODS OF CLEARING MINEFIELDS

a. Introduction. To clear a mine field is to remove or destroy all mines, enemy or friendly, in the field. The methods used in mine clearance are similar to those in breaching, but are more deliberate and carefully applied. Minefield records are used to the maximum. Brush and other cover in the minefield area may be removed by burning.

b. By Probing. To clear small nonmetallic mines from an enemy field or a friendly field for which records are unavailable, the procedure described here is to be considered as guide only. The platoon is used as the basic unit, and mines are blown in place or removed by rope.

(1) The platoon is organized as shown in table 21. The clearing parties operate as depicted in figure 56.

(2) The use of explosive is described in paragraph 36b.

(3) Rope removal is safer than removing mines by hand. See figure 57 for illustrations of this method. Proceed as follows.

(a) Uncover top of mine.

(b) Attach rope or wire at least 45 meters long to mine.

(c) Make sure all personnel nearby have taken cover.

(d) Take cover at least 45 meters from mine and pull it from hole. (Make sure the place of cover, such as a foxhole, is checked for enemy booby-traps prior to this action.)

(e) Wait 30 seconds before approaching mine.

(f) Recheck hole for additional mines.

(g) Remove fuze or cut the firing chain.

(h) Carry mine to a dump for disposal or reuse.

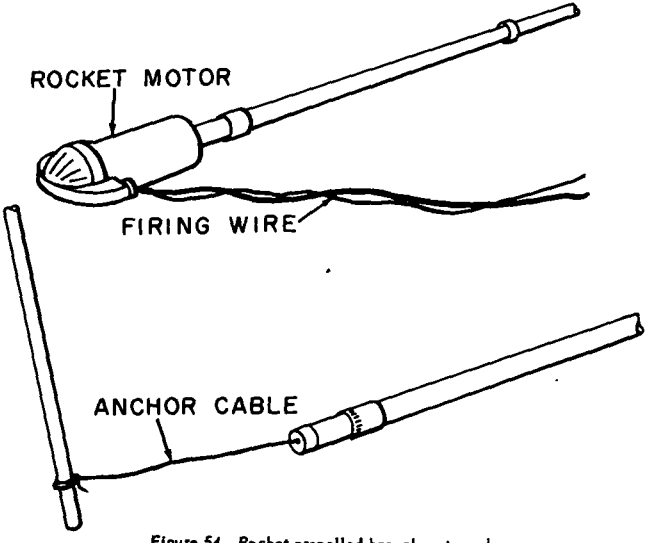


Figure 54. Rocket-propelled bangalore torpedo.

Table 20. Platoon Organization and Equipment for Manual Breaching

Personnel	Officer	NCO	EM	Equipment
Officer in charge	1	- - -	- -	Lensatic compass, map, radio, and individual weapon
Platoon sergeant	- - - -	1	- -	Same as OIC, except no radio
No. 1 breaching party	- - - -	1	7	2 portable detectors, 2 probes, mine markers, marking tape or wire on reels, safety pins, clips, smooth wires (18" lengths), ½-lb blocks of explosive, blasting caps, detonating cord, safety fuze, fuze lighters, crimpers, and portable radio
No. 2 breaching party	- - - -	1	7	Same as No. 1 breaching party
No. 3 breaching party	- - - -	1	7	Same as No. 1 breaching party
Support party	- - - -	1	10	Same as No. 1 party, plus: sledges or mauls, hammers, pliers, wirecutters, 2" by 4" stakes at least 6' long, individual weapons, litters, lane-marking signs, gauntlets, barbed wire, stakes and pickets.
TOTAL	1	5	31	

NOTE: Under chemical warfare conditions, personnel require protective clothing to include impregnated boots. Each individual will carry the protective mask and protective gloves, ready for immediate donning, upon discovery of a toxic chemical mine. Decontamination and specialized first aid equipment should also be at hand.

Table 21. Platoon Organization and Equipment for Manual Clearing

Personnel	Officer	NCO	EM	Equipment
Officer in charge	1	- - -	- -	Map, lensatic compass, portable radio, and all available information on mines in area.
No. 1 clearing party	- - - -	1	10	Mine probes, tracing tape on reels, mine markers, grapnels, rope or wire in 45 meters lengths, 45-cm lengths of 10-and 16-gage wire, demolition equipment, shovels or entrenching tools, and portable radios
No. 2 clearing party	- - - -	1	10	Same as No. 1 clearing party
No. 3 clearing party	- - - -	1	10	Same as No. 1 clearing party
Control party	- - - -	1	2	Map, lensatic compass, portable radio (2 preferably, 1 for platoon and 1 for company net)
TOTAL	1	4	32	

NOTE: Under chemical warfare conditians, personnel require protective clothing to include impregnated boots. Each individual will carry the protective mask and protective glaves, ready for immediate donning, upon discovery of a taxic chemical mine. Decontamination and specialized first aid equipment should also be at hand.

c. By Use of Detectors.

(1) The platoon is organized the some as for probing, except that each clearing party has three electrical mine detectors and is reduced by one man. The duties and procedures are basically the same as for probing.

(2) Figure 58 shows the clearing party in action, using electrical detectors.

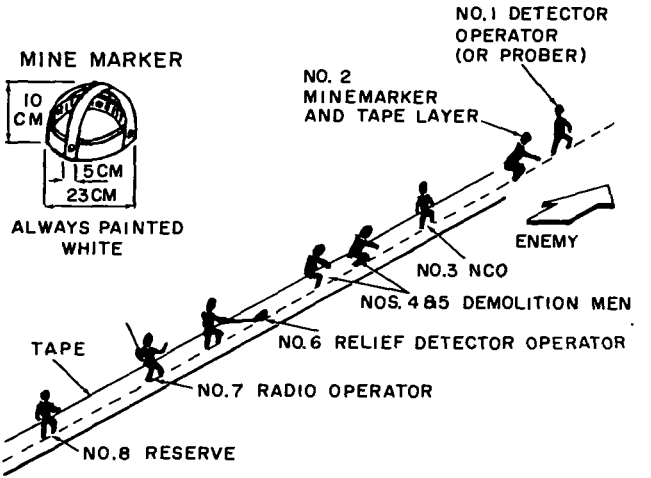


Figure 55. Minefield-breaching party. Men are numbered only to indicate their entry into the field.

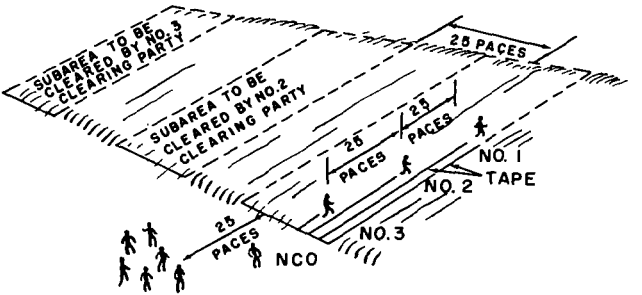


Figure 56. Number 1 clearing party in operation.

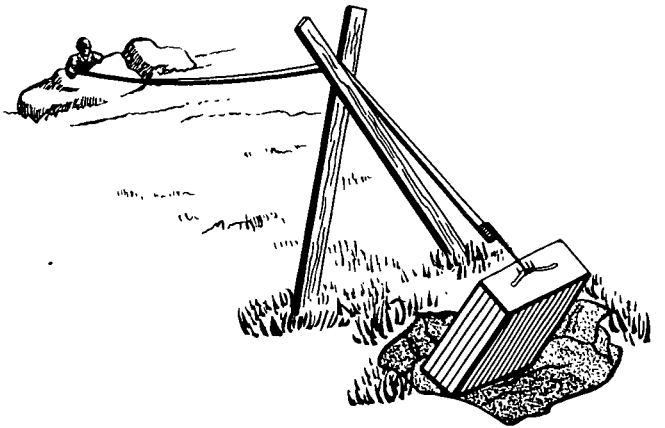


Figure 57. Using A-frame to remove mines.

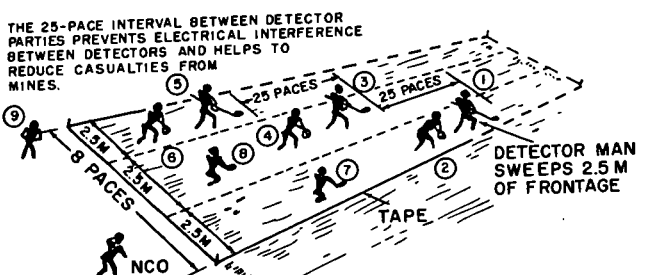


Figure 58. Clearing party using electrical detectors.

CHAPTER 4

FIELD FORTIFICATIONS

Section I. Layout and Methods

38. PRIORITY OF TASKS

Many of the jobs involved in preparing a defensive position are carried on concurrently, but some will be executed in priority. The commander, therefore, specifies the sequence for the preparation of the position and any special precautions to be taken regarding camouflage. The following is a recommended sequence.

a. Establishing security.

b. Positioning weapons.

c. Clearing fields of fire, removing objects, masking observation and determining ranges to probable target locations.

d. Providing for signal communications and observation systems.

e. Laying minefields and preparing important demolitions.

f. Preparing weapons emplacements and individual positions to include overhead cover, and camouflaging them concurrently.

g. Preparing obstacles (other than minefields) and less vital demolitions.

h. Preparing routes for movement and for supply and evacuation.

i. Preparing alternate and supplementary positions.

j. Preparing CBR protective shelters as required.

k. Preparing deceptive installations in accordance with deceptive plans of higher headquarters.

39. CLEARING FIELDS OF FIRE

In all cases, when preparing defensive positions for expected contact with the enemy, suitable fields are cleared to the front of each position. The following principles are observed:

a. Principles. Do not disclose friendly positions by careless or excessive clearing.

(1) When organizing for close defense, start clearing near the FEBA and work forward at least 100 meters.

(2) Leave a thin, natural screen to hide defensive positions.

(3) In sparsely wooded areas, remove lower branches of large scattered trees, or remove entire trees which might be used as reference points.

(4) Do not completely clear fields of fire in heavily wooded areas. Thin down the undergrowth, remove lower branches of trees, and clear narrow lanes of

fire for automatic weapons.

(5) Remove or thin out thick brush.

(6) Remove hay or grain crops by mowing.

(7) Drag away cut brush.

b. **Manhours Required.** The manhours required to clear 100 square meters are tabulated in table 22.

Table 22. Manhours Required to Clear 100 Square Meters

Description of clearing	Tools used	Manhours required*
Medium clearing: Clearing undergrowth and trees less than 12" in diameter	Saws, axes	5
Light clearing: Clearing small brush	Axes, brush-hooks, machetes, and hatchets	2.5

* Figures are for daylight; for work at night, increase labor by 50 percent

40. EXCAVATION

a. **Time and Labor for Constructing Entrenchments.** Information is presented in table 23.

Table 23. Time and Labor for Constructing Entrenchments[1]

	1	2	3	4
1	Type of emplacement	Excavation cu meters	No. of men working	Approximate time, hr[2]
2	Crawl trench (per linear meter)	0.5	3	¼
3	Standard trench (per linear meter)	1.5	3	2/3
4	Prone emplacement	0.7	1	1
5	1-man foxhole	1	1	2
6	2-man foxhole	1.8	2	1½

[1] When ditching machines are used for excavating, use the following data:

a. Width of cut 0.6 meter.

b. Maximum depth of cut 1.8 meters

c. Excavation rate up to 2.4 lineor meters per minute, depending on the type af soil ond depth of cut.

d. For general planning, use 0.5 cubic meters of earth removal per minute in soil of medium hardness.

e. For high-speed ditching machine, the excavation rate is 3.6 to 6.1 lineor meters per minute at o depth of 1.8 meters.

[2]Time pertains to average, unfrozen soil.

b. Excavation ond Camouflage Data for Emplacements. This data is presented in table 24.

Table 24. Excavation and Camouflage Data

	1	2	3	4	5
1	Weapon	Type of emplacement	Area to be camouflaged, meters	Excavation, cu meters	Manhours required to construct in medium soil*
2	Rifle, US, cal 7.62-mm, M14	Foxhole	3 x 3	1	2
3	Rifle, 7.62-mm, M14M	Foxhole	3 x 3	1	2
4	Launcher, rocket, 3.5-in	Pit 2 Foxhole	1.5 x 1.5 4.5 x 4.5	1.5 2.7	2 4
5	Machinegun, 7.62-mm	Horseshoe 2 foxhole	4.5 x 4.5 4.5 x 4.5	3.5 2.0	7 4
6	Mortar, 81-mm, on mount	Pit	4.8 x 4.8	3	6
7	Rifle, 106-mm, jeep-mounted	Pit	9.7 x 6.1	11	30

*Figures ore for daylight; for work ot night, increase labor by 50 percent. Time pertains to average, unfrozen soil.

41. INTRENCHMENTS AND EMPLACEMENTS

a. Standard Types. These types meet the following requirements:

(1) Permit each individual or each weapons crew to accomplish assigned fire missions.

(2) Be simple and easily constructed.

(3) Provide maximum protection with minimum time and labor.

(4) Be camouflaged and concealed.

(5) Provide protection against mechanized attack.

(6) Provide protection against nuclear attack.

Illustrations of these intrenchments and emplacements are in figures 59 through 65.

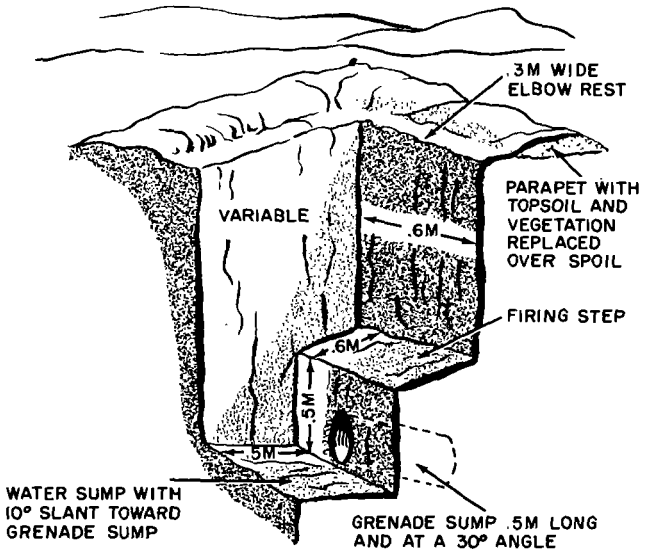


Figure 59. Open one-man foxhole.

b. Retoining-Wall Type Revetments. This type of revetment is used in relatively unstoble soils. The horizontal loyers of the wall are tied together so that the woll acts as o structurol unit without any sliding of one part upon another. This type of revetment (fig. 66) may be constructed of sandbogs, sod blocks, ond various expedients as described below. The methods of building each of the types of this revetment ore os follows:

(1) Sandbags ore useful for temporory revetments. Loy them os follows:

(a) Fill to three-fourths of full copacity.

(b) Place o double row of alternote headers ond stretchers as shown in figure 66.

(c) About 340 sandbags are ploced per 100 squore meters of revetted surface.

(d) Stabilize bogs by filling them with 1 part cement to 10 parts dry earth; in a sand-gravel mixture, increase ratio to 1 to 6.

(e) Tuck in bottom corner of bags ofter filling.

(f) Slope the wall toward revetted foce at slope of 3 or 4 to 1.

(g) With stobilized sondbogs the foundation shauld be about 15 centimeters below floor level.

(h) Ploce bags perpendicular to slope.

(i) All bags on bottom row ore ploced as headers (fig. 66).

(j) Alternote intermediate rows as headers and stretchers.

(k) Top row is of headers.

(l) Ploce side seoms and choked ends on inside.

(2) Sod blocks of thick sod with good roots provide sotisfactory revetting moteriol. Cut sod blocks into 20-by 45-centimeter sections ond loy them flot, using the olternate stretcher-method os with sondbogs ((1) above). Lay sod grass-to-grass and soil-to-soil, except for the top loyer which is ploced with grass upword for comouflage purposes. Drive two wooden pegs through eoch section of every loyer os it is completed. Loy this sod revetment ot a slope of 3 to 1.

(3) Expedients may be used, such as ice blocks in cold weother. They ore stacked the same as sandbags or sod. Woter is run over them to bind by freezing. Another expedient is earth-filled packing coses or ammunition boxes, which are placed in position and nailed to the loyer below. The boxes ore then filled with eorth or rock. In wooded areas, small timber moy be used os revetting moteriol.

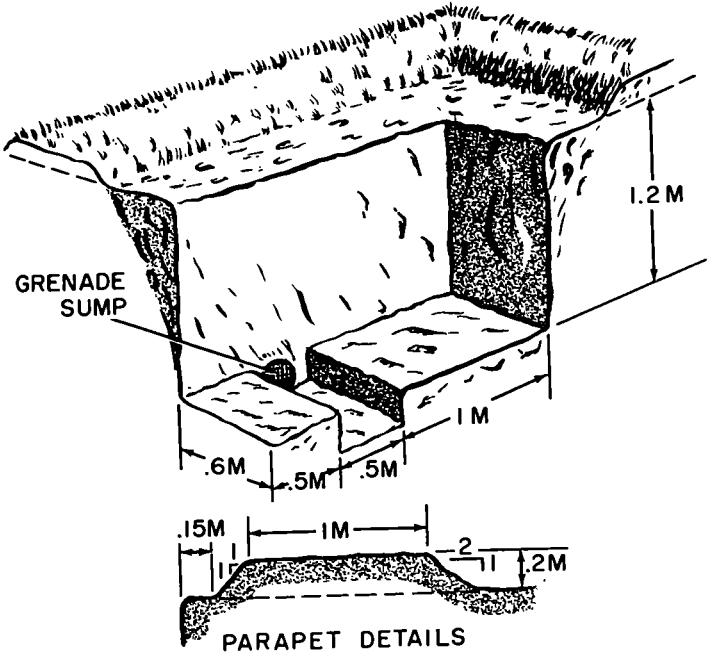


Figure 60. Open two-men foxhole.

c. Fecing Type. This type af revetment serves mainly te pretect revetted surfeces fram weether and damege ceused by occupetion. The soils must be steble enaugh ta sustein their weight. This revetment consists af fecing (revetting) meteriel and suppart which hald this materiel in plece (fig. 67). The tap af the facing is set belaw ground level sa thet the revetting is nat damaged by tanks crassing the emplacement.

(1) Materials used in facing may be made of brushwood bundles, continuous brush, pole and dimensioned timbers, corrugated metal, or burlap and chicken wire. Construction methods of each type are described in (3) below.

(2) Methods of support include:

(a) Timber frames of dimensioned timber (fig. 68) are built to fit the bottom and sides of the position and hold the facing material apart. This insures that the excavated width remains stable.

(b) Pickets are driven into the ground on the position side of the facing material and held tightly against the facing by bracing the pickets apart.

(3) Methods of constructing facing type revetments are:

(a) The size of pickets depends upon the soil type and the kind of facing material, but the pickets should not be smaller than 7.6 centimeters in diameter. Maximum spacing between pickets should be 1.8 meters. The U-shaped pickets used for barbed wire are excellent for revetting.

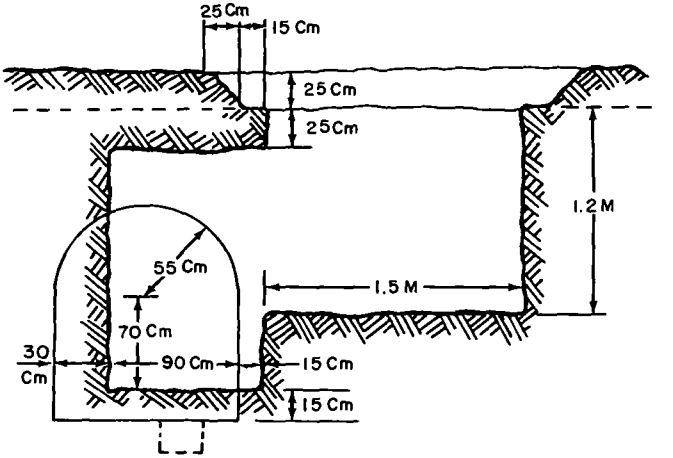


Figure 61. Two-man foxhole with half cover and adjoining shelter.

Pickets are driven at least 0.45 meters into the floor of the position. Where the pickets are anchored at the top, proceed as shown in figure 68. Alternate anchors are staggered and at least .61 meters farther back.

(b) A brushwood bundle (hurdle) is a woven revetment unit usually 1.8 meters long and of required height. Figure 69 shows how to build the framework. When completed, the 1.8-meter lengths are pulled up and carried to their position.

(c) A continuous brushwood revetment is built in place. Details are pictured in figure 70.

(d) The pole revetment is similar to the continuous brush revetment, except that a layer of small horizontal round poles cut to wall length is used. If available, boards or planks are used.

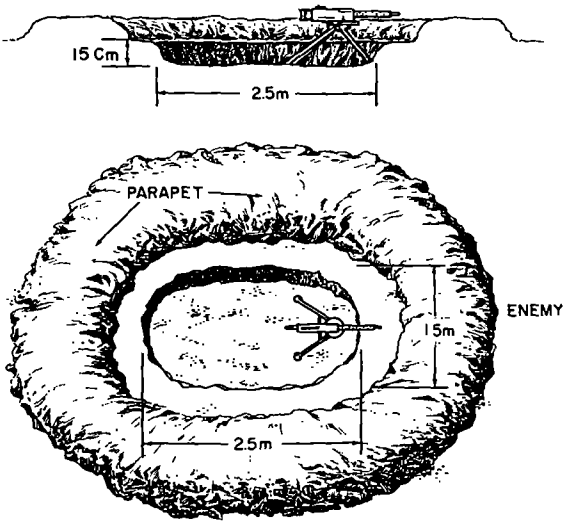


Figure 62. Plain view and cross-section of pit type emplacement for caliber .30 machinegun.

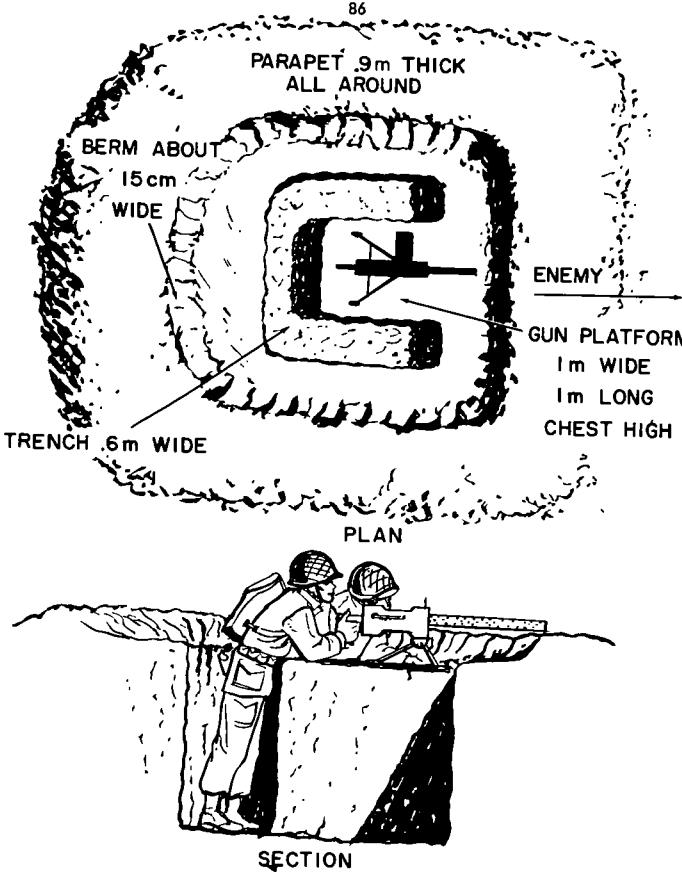


Figure 63. Completed horseshoe type emplacement.

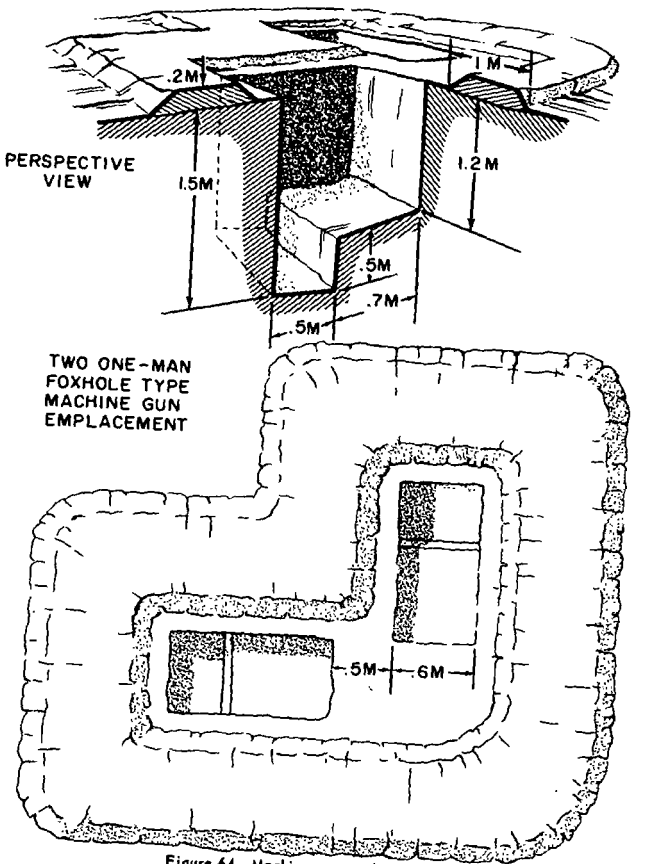


Figure 64. Machinegun emplacement.

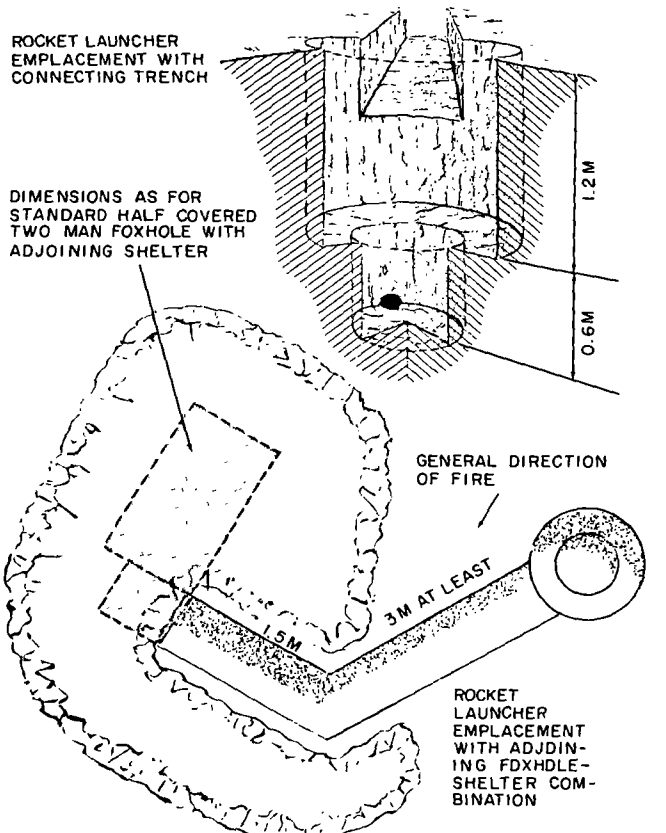

ROCKET LAUNCHER EMPLACEMENT WITH CONNECTING TRENCH
DIMENSIONS AS FOR STANDARD HALF COVERED TWO MAN FOXHOLE WITH ADJOINING SHELTER
1.2M
0.6M
GENERAL DIRECTION OF FIRE
3M AT LEAST
1.5M
ROCKET LAUNCHER EMPLACEMENT WITH ADJDIN-ING FDXHDLE-SHELTER COM-BINATION

Figure 65. Rocket launcher emplacement.

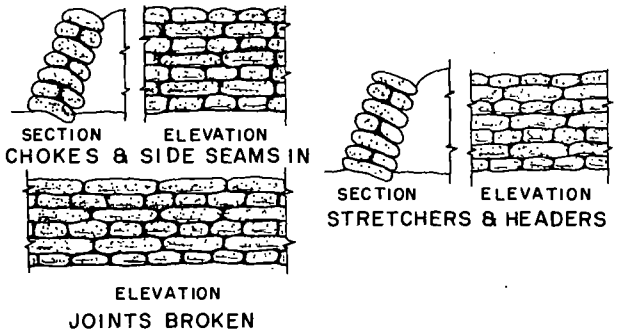


Figure 66. Retaining-wall type of revetment.

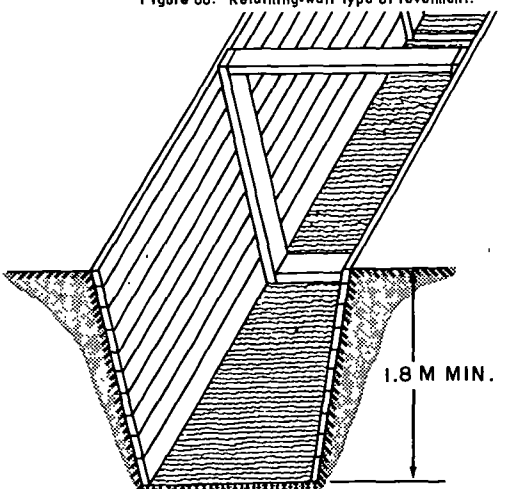


Figure 67. Facing type revetment, supported by frame.

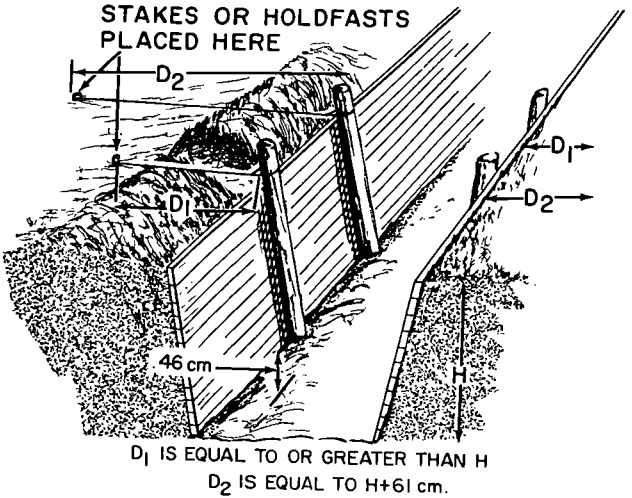


Figure 68. Method of anchoring pickets.

(e) Corrugated metal sheets or pierced steel plank are strong, durable, and are rapidly installed. They may be used for any height or length of revetment. Smear metal surfaces with mud to eliminate possible reflection of thermal radiation and to aid camouflage.

d. Specialized Types. Specialized types of intrenchments and emplacements may be developed progressively from the standard types described above (a through c). These are needed when operations demand a perimeter defense. Features such as overhead cover and grenade sumps may be used to protect personnel.

e. Minefields. In constructing field fortifications and the obstacles associated with them, minefields not only present an impediment to the advance of the enemy, but can inflict casualties. Minefields change favorable terrain to unfavorable terrain and materially strengthen the defense system. See chapter 3 for information on mines and minefields.

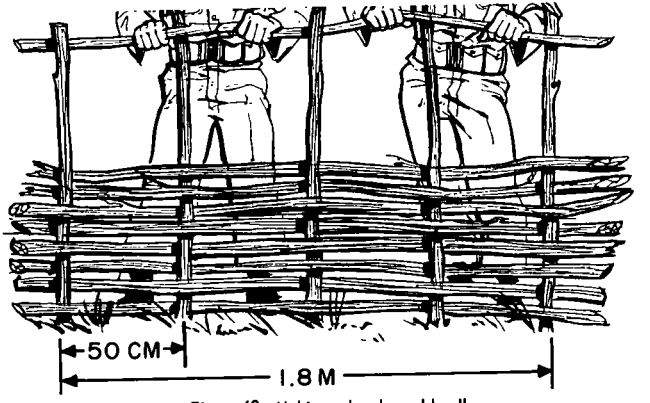


Figure 69. Making a brushwood hurdle.

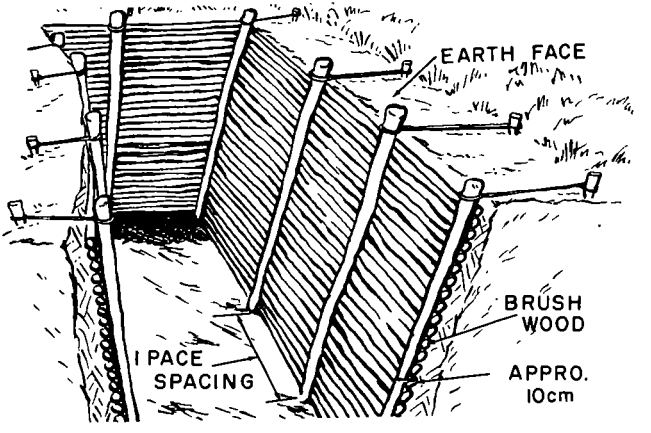


Figure 70. Continuous brushwood revetment.

Table 25. Material Thicknesses in Centimeters Needed for Protection Against Direct Hits by Direct-Fire Weapons

Material	Small-arms and machine-gun (7.92-mm.) fire at 100 m[1]	Antitank rifle (7.92-mm.) fire at 100 m	20-mm. antitank fire at 200 m	37-mm antitank fire at 400 m.	50-mm antitank fire at 400 m	75-mm direct fire, 500 to 1,000 m	88-mm. direct fire, 500 to 1,000 m.	Remarks
Solid walls.[2]								
Brick masonry.	45	60	76	152	.....	.....	.....	
Concrete, not reinforced[3]	30	45	60	107	120	137	198	Plain, formed-concrete walls.
Concrete, reinforced	15	30	45	90	107	120	198	Structurally reinforced
Stone masonry	30	45	76	107	137	152	.....	These figures can be taken as guides only
Wood	60	90	120	.....	.....	.....	.....	These figures can be taken as guides only.
Timber	90	152	.....	.....	.....	.....	.....	These figures can be taken as guides only
Walls of loose material packed between boards:[2]								
Brick rubble	30	60	76	152	180	.....	.....	
Clay, dry	90	120	.....	.....	.....	.....	.....	Add 100% if wet
Loam, dry	60	90	120	.....	.....	.....	.....	Add 50% if wet.
Gravel or small crushed rock	30	60	76	152	180	.....	.....	
Sand, dry	30	60	76	152	180	.....	.....	Add 100% if wet.
Sandbags filled with:								
Brick rubble	51	76	76	152	178	.....	.....	
Clay, dry	102	152	.....	.....	.....	.....	.....	Add 100% if wet.
Loam, dry	76	127	152	.....	.....	.....	.....	Add 50% if wet
Concrete, gravel or small crushed rock	51	76	76	152	178	.....	.....	
Sand, dry	51	76	76	152	178	.....	.....	Add 100% if wet.
Loose parapets of:[2]								
Clay	107	152	.....	.....	.....	.....	.....	Add 100% if wet
Loam	90	120	152	.....	.....	.....	.....	Add 50% if wet
Sand	60	90	120	.....	.....	.....	.....	Add 100% if wet

NOTE Protective thicknesses given are for a single shot only (except [1]) Where direct fire weapons are able to get five or six hits in the same area, the required protective thickness is approximately twice that indicated

[1] One burst of five shots

[2] Thicknesses given to nearest 15 cm

[3] For 3,000 psi concrete.

42. PROTECTION AGAINST SHELLS AND BOMBS

a. Prefabrication. Items adepted to prefabrication include stonderd frames, stondord sheathing, members for emplacements of post-cop construction, and members for modular shelter sections. Plonning for this type of operation begins with o study of the work to be done and the meons avoiloble. Drowings are made, showing cuts to be made on eech member ond the finished dimensions. Further detoils moy be reod in FM 5-15.

b. Protection Against Direct-Fire Weapons. The thickness of cover needed for pratection ogoinst direct hits by direct-fire weepons is tabuleted in toble 25.

Table 26. Material Thicknesses in Centimeters Needed Against Projectiles and Bombs Exploding 15 Meters Away

Material	High-explosive shells and rockets			General-purpose bombs			
	75-mm	105-mm	155-mm	100-lb	250-lb	500-lb	1,000-lb
Solid Walls:							
Brick masonry.	10	15	20	20	25	33	43
Concrete, ploin	10	13	15	20	25	38	46
Concrete, reinforced. . . .	8	10	13	18	23	30	38
Timber. . . .	20	25	36	38	46	60	76
Walls of loose material between boards:							
Brick rubble. .	23	25	30	45	60	71	76
Gravel, small stones. . . .	23	25	30	45	60	71	76
Earth[1]	38	45	60	60	76	---	---
Sandbags filled with:							
Brick rubble. .	25	25	50	50	50	76	100
Gravel, small stones. . . .	25	25	50	50	50	76	100
Sand[1]	25	25	50	76	76	100	100
Earth[1]	50	50	76	76	100	100	127
Parapets of:[2]							
Sand[1]	30	45	60	60	90	90	120
Earth[1]	60	90	120	90	120	152	----

[1] Figures based on dry material. If wet material, double figures.

[2] Figures given to nearest 15 cm.

c. Protection Against Projectiles and Bombs Exploding 15 Meters Away. See table 26.

d. Protection Against Nuclear Weapons.

(1) Personnel need protection against the effects of blast, nuclear radiation, and thermal radiation. Although such natural shelters as caves, mines, and tunnels may be used by troops as protection against nuclear weapons, the information here is confined to artificial shelters of both the surface and subsurface types. Whatever type is used in a particular situation depends upon the character of the ground, the protection required, and the materials available.

(2) Surface shelters should be of small capacity (2 to 12 men) and well dispersed.

(a) Wooden shelters are not a good protection against nuclear blast. The fire hazard is an important consideration. Against initial and residual radiation the transmission factors have been determined as follows:

Earth cover thickness, m	Initial gamma, roentgens	Residual, roentgens
0.45	0.20	0.02
0.75	0.08	0.009
1.0	0.04	0.004

Neutron transmission factors are about the same as, or slightly less than, prompt gamma transmission factors.

(b) Metal surface shelters are superior to wooden because they are usually arched and more rapidly erected. Compare the data below for metal surface shelters with that in (a) above for wooden shelters.

Earth cover thickness, m	Initial gamma, roentgens	Residual, roentgens
0.45	0.10	0.015
0.75	0.07	0.004
1.0	0.03	0.003

(3) Subsurface shelters provide better protection; they are not subjected so much to blast effects. Protection against radiation is also improved because of the surrounding earth.

(4) Cut and cover shelters are found most commonly in a forward area. Their protection depends on the construction, thickness, and overhead cover. These shelters are suitable for command posts and aid stations.

(5) Cave shelters are made below the surface by mining methods. They are effective protection and require the least material, although they consume much time to build and troops may be trapped in them.

(6) Safe distances for complete protection afforded by various shelters without cover from a nuclear explosion whose explosive force is equal to 20,000 tons of TNT are given in table 27. The distances shown are measured along the ground from the point directly under the burst of a nuclear device. It is assumed that the bomb is burst at a height of 760 meters above the ground on a clear day. When the explosion is greater than 20 KT, for example 30 KT, the following factors are used to determine safe distances: $\sqrt[3]{\frac{KT}{20}}$ multiplied by distances in table 27.

(7) In the absence of fortifications with overhead cover the best and quickest protection for the individual is the one-man standing foxhole (fig. 71). With cover, the effectiveness against gamma radiations depends mainly upon the density and thickness of the covering material.

Table 27. Safe Distances from 20-KT Explosion

Standing in open	4000 meters
Lying flat in open	2700 meters
Lying behind low wall	1600 meters
Lying behind small hill	1150 meters
Lying in ditch	1150 meters
Lying in culvert	900 meters
Ordinary foxhole	900 meters

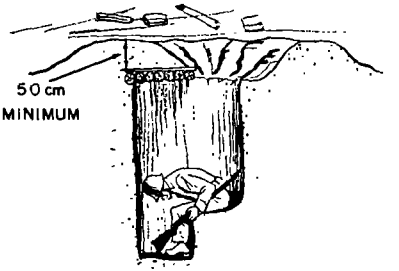


Figure 71. Foxhole protection from nuclear blasts.

Section II. Wire Obstacles

43. ESTIMATING BARBED WIRE REQUIREMENTS

When the length of front is taken as the straight-line distance between limiting points, the rules are:

a. Tactical Wire. Length of tactical wire entanglement is 1¼ times the length of front, regardless of the size of the unit involved.

b. Protective Wire. Length of protective wire entanglement is 5 times the length of the front being defended. Because protective wire encircles each platoon area, the protective wire for units is 2½ times the average platoon frontage, times the number of platoons.

c. Supplementary Wire. Supplementary wire in front of the FEBA breaks up the line of tactical entanglements. It is 1¼ times the unit's frontage. Behind the FEBA, the length of supplementary wire is about equal to 2½ times the distance from the FEBA to the rearmost reserve unit.

44. WIRE ENTANGLEMENT MATERIALS

See table 28.

Table 28. Wire Entanglement Materials

Material		Approx weight, Kg	Approx length, M	No. carried by 1 man	Approx weight of man-load, Kg
Reel		47.5	366	½	24
Babbin		3.5-4.0	27.5	4-6	14.5-24.5
Standard barbed-wire concertina		25	15.2	1	25
Expedient barbed-wire concertina		13.5	6.1	1	13.5
Screw pickets	Long	4	1.6	4	16.3
	Medium	2.7	0.81	6	16.3
	Short	1.8	0.53	8	14.5
U-shaped pickets	Extra Long	7.25	2.4	3-4	21.8-29.0
	Long	4.5	1.5	4	18.1
	Medium	2.7	0.81	6	16.3
	Short	1.8	0.61	8	14.5
Wooden pickets	Extra Long	7.7-10.5	2.13	2	15.4-20.8
	Long	5.4-7.25	1.5	3	16.3-21.7
	Short	1.4-2.7	0.75	8	11.0-21.7

45. MATERIAL AND LABOR REQUIRED

a. See table 29.

b. For a sample estimate of material and labor required to organize a given defensive position, see FM 5-15.

46. ORGANIZATION OF CREWS

a. Operations. In the erection of triple-belt standard concertina in units of 300 meters or less, a 300-meter section is a platoon job normally requiring less than 1 hour. There are two operations, as expressed below. Each group comprises about one-third of the platoon.

(1) For the first operation, one group lays out all pickets, one installs all pickets, and one lays out all concertina rolls. The front-row long pickets are laid out at 4-meter intervals. Then the rear-row long pickets are laid out 1 meter to the rear and opposite to the center of interval between the front-row long pickets. At each end of each line an anchor picket is laid out 1.5 meters from the end long picket. The second group installs the pickets along the front row first. The third group lays out the concertinas along the rows of pickets. One roll is placed at the third picket in the front row, and one at every fourth picket thereafter. There are 16 staples for each front-row concertina. Two rolls are placed in the second row at the third picket, and two at every fourth picket thereafter.

(2) As they complete the first operation all men are organized in four-man parties to open and install the concertinas, beginning at the head of the fence. The sequence of this task is shown in figure 72. It proceeds as follows:

(a) Open the front-row concertinas in front of the double line of pickets and the other two in its rear.

(b) Lift each front-row concertina and drop it over the long pickets, then join the concertina ends as shown in figure 73.

(c) Fasten the bottom of the concertina to the ground by driving a staple over each pair of end hoops, and one over the bottom of a coil at each long picket, and one at the one-half and one-quarter points of the 4-meter picket spacing.

(d) Stretch a barbed-wire strand tightly through inside the concertina in order to assist in supporting the concertina coils.

(e) Install the rear-row concertina and stretch a horizontal wire along the tops of the rear row of pickets.

(f) Install the concertina in the top row (fig. 72), fastening the end hoops of 15.2-meter sections with plain steel wire ties. Begin this row at a point between the ends of the front and rear of the lower rows.

Table 29. Material and Labor Requirements for 300-meter Sections of Various Barbed-Wire Entanglements

Type of entanglement	Pickets				Barbed wire, no. of 400 m, 47.5-Kg reels[1]	No. of concertinas[4]	Staples	Kgs of materials per lin m of entanglement[2]	Man-hours to erect 300 m of entanglement[3]
	Extra lang	Lang	Medium	Short					
Double-apron, 4- and 2-pace	-	100	-	200	14-15	-	-	4.9	59
Double-apron, 6- and 3-pace	-	66	-	132	13-14	-	-	3.5	49
High wire (less guy wires)	-	198	-	-	17-19	-	-	5.9	79
Low wire, 4- and 2-pace	-	-	100	200	11	-	-	3.7	49
4-strand fence	-	100	-	2	5-6	-	-	1.9	20
Double expedient concertina	-	101	-	4	3	100	295	6.9	40
Triple expedient concertina	51	101	-	7	4	148	295	10.4	99
Triple standard concertina	-	160	-	4	3	59	317	7.9	30

[1] Lower number of reels applies when screw pickets are used; high number when U-shaped pickets are used. Add difference between the two to the higher number when wood pickets are used.

[2] Average weight when any issue metal pickets are used.

[3] With the exception of the triple-standard concertinas, man-hours are based on the use of screw pickets. When driven pickets are used, add 20 percent to man-hours. With experienced troops, reduce man-hours by one-third. Increase man-hours by 50 percent for night work.

[4] Based on concertinas being made up in rear areas and ready for issue. One expedient concertina opens to 6-meter length, as compared with 15 meters for a standard concertina; it requires 92 meters of standard barbed wire, also small quantities of No. 16 smooth wire for ties.

(g) Rack the top concertino to the rear horizontal wire at points halfway between the long pickets.

b. Erection of 4- and 2-Pace Double-Apron Fence in Units of 300 meters or Less. There are two types of double-apron fence, the 4- and 2-pace, and the 6- and 3-pace. The former is the better obstacle and more commonly used. Set the center pickets 4 paces apart and the anchor pickets 2 paces from the line of the center pickets in positions shown in figure 74. The construction of a 300-meter section of either type of double-apron fence is a platoon (36 men) task normally requiring 1½ hours. There are two operations: laying out and installing pickets, and installing wire. The second operation begins as men become available.

(1) In the first operation, the working party is divided into three groups of about equal size. One group lays out the long pickets along the centerline of the fence at 4-pace (3-meter) intervals on the spot where they will be installed. Another group places the anchor pickets, positioned 2 paces (1.5 meters) each way from the centerline. The third group installs all pickets, and is helped by other members of the first and second groups as they finish laying out the pickets.

(2) As the groups complete the first operation, they begin installing wire. Wires are installed in the order given in figures 74 and 75. The men are divided into 2- or 4-man groups and proceed to install the wires in numerical order as follows:

(a) The No. 1 wire is the diagonal wire on the enemy side and is fastened by a top-eye tie to all pickets or by the post tie if expedient pickets are used.

(b) The No. 2 wire is the tripwire on the enemy side. It is secured to both diagonals just above the anchor picket with the apron tie. It should be tight and within a few inches of the ground.

(c) No. 3 is an apron wire on the enemy side. Secure it to the first diagonal wire (No. 1), to each alternate diagonal, and then to the last diagonal wire. No. 4 wire is also an apron wire on the enemy side. It is secured to No. 1 wire, to the diagonal wires to which No. 3 is not tied, and then to the last diagonal wire.

(d) No. 5 wire is not started from the end anchor picket, but at the first long picket. It is secured with the intermediate eye tie or with the post tie if expedient pickets are used.

(e) Nos. 6, 7 and 8 wires complete the center portion, and are secured to the long pickets. These wires form the backbone of the fence.

(f) No. 9 is the diagonal apron wire on the friendly side of the fence and is secured to all pickets. Nos. 10 and 11 are apron wires, and No. 12 is the tripwire on the friendly side. No. 12 is installed in the same way as No. 2 wire.

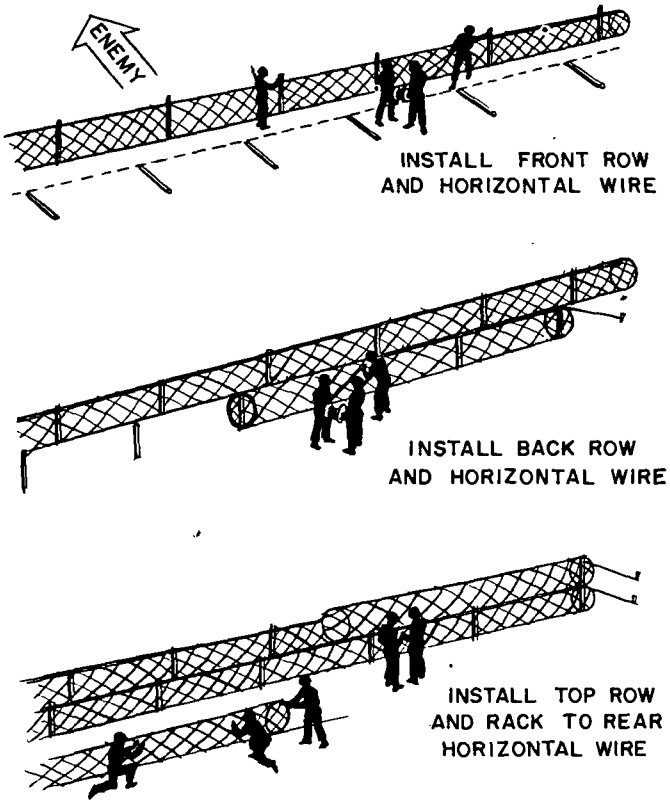


Figure 72. Installing concertinas.

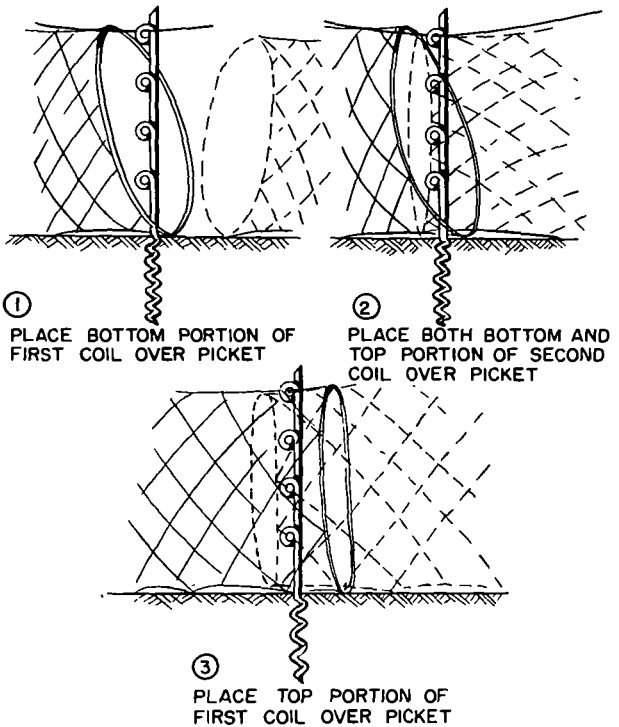

①
PLACE BOTTOM PORTION OF FIRST COIL OVER PICKET
②
PLACE BOTH BOTTOM AND TOP PORTION OF SECOND COIL OVER PICKET
③
PLACE TOP PORTION OF FIRST COIL OVER PICKET

Figure 73. Joining concertinas.

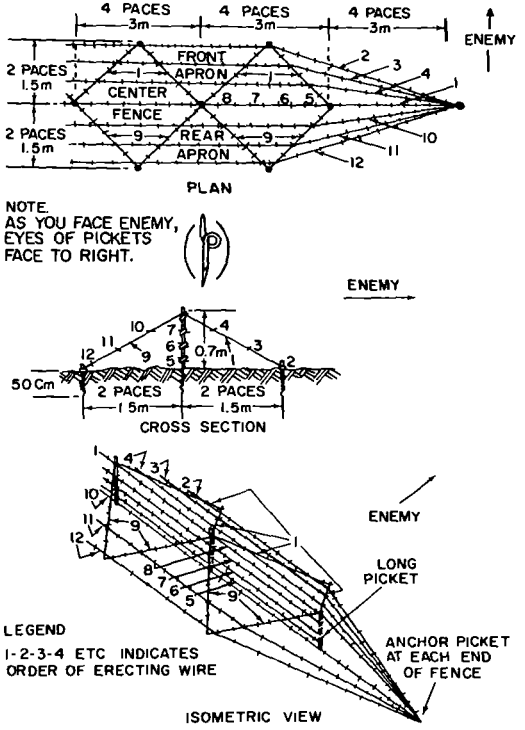


Figure 74. Double-apron fence.

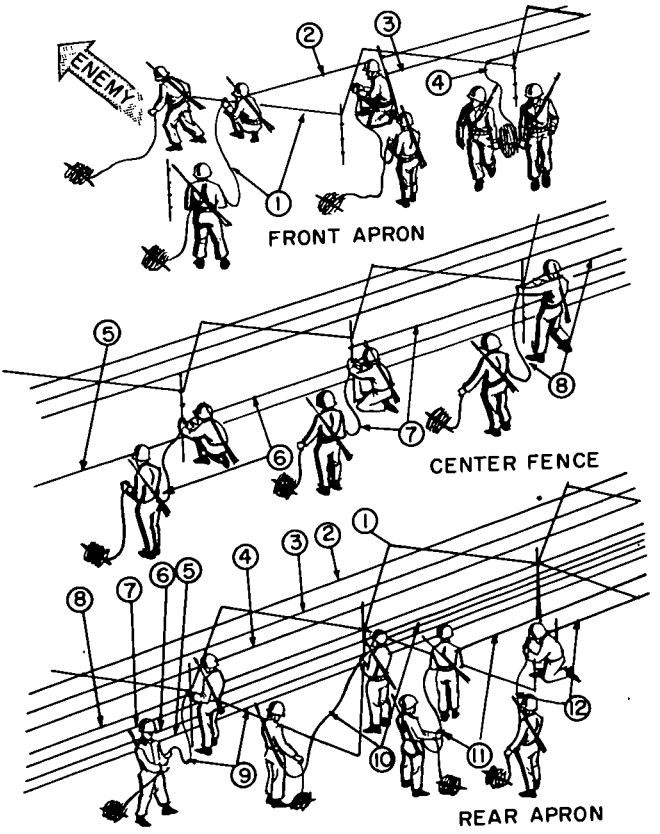


Figure 75. Sequence of installing wire in double-apron fence.

c. Low Wire Fence. This is like o 4- ond 2-poce double opron fenco, except thot medium pickets instead of long pickets ore used in the centerline (fig. 76). The Nos. 5, 6, and 7 wires ore not used, which rosults in oll apron and diogonol wires being much closer to the ground. Being low to the ground, this obstocle is easily hidden in toll gross or shallow woter. For best results, it should be used in depth.

d. Four-Strand Cattle Fence. This is the four-strond center section of a double-apron fence. In farm country, such on obstocle blends with the londscope. Wooden pickots at 2- to 4-poce intervals ore set up. If guy wires ore used, they should be odded seporotely when estimoting becouso this moteriol is not included in the amounts listed in toble 29.

(1) Use eight men on short sections of this fonce. On 300-meter sections, use up to 17 men.

(2) In the first operotion the working porty is divided into two opproximotely equol groups. The first group loys out long pickets ot 3-meter intervols. It begins ond ends the section with on anchor picket, including anchor pickets for guys, if needed. The second group instolls the pickets.

(3) As eoch mon completes the first operotion, he moves to the fence. Thsse teoms of two or four men are orgonized to instoll wires. In four-mon teams, two men corry the roel, ond two moke ties and tighten the wiro. In the two-mon teoms, the wire is unrolled for 50 to 100 meters, then tho mon moke the ties. The first teom instolls the bottom wire, ond succeeding teams instoll the next wires in order.

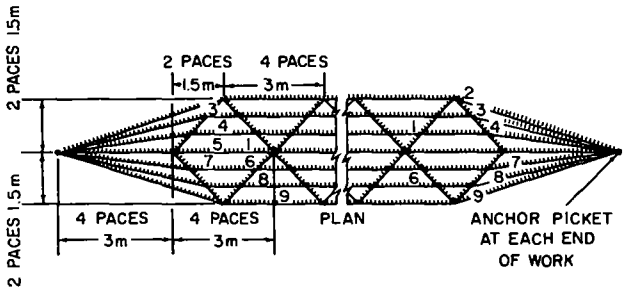
e. Combination Bands. Mony types of fences may be combined in bands to form obstocles more difficult to breach than single belts. Several types of effoctive combinotion bonds ore shown in figure 77. Other voriotions moy bo readily developsd.

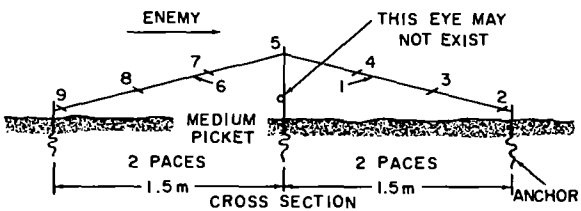
f. Portable Borbed-Wire Obstacles. Standord concertinos ore in this category becouse they ore reodily moved. Other portoblo borbed-wire obstocios ore:

(1) Spirals of loose wire are used to fill open spoces in ond betwoen wire entonglements. Prepore them by driving four 1-meter posts into the ground to form o diomond 1 moter by .5 meter. Wind 75 meters of wire oround them from bottom to top. Remove wire from the frome, tie it ot tho quorter points, then bond them to the site where they ore opened ond usod.

(2) The knife rest (fig. 78) is o portable wooden or metol frome strung with borbed wire. It is about 4.5 meters long ond 1.2 meters high. It must be securoly fixod in position.

(3) Right after a defensive position is occupied and bofore protective wire is erected, trip wires should be ploced just outside of grenado ronge (obout 30 or 40 meters). Stretch the wires obout 25 centimetors obove the ground ond stretch on pickots ot 1.5-meter intervols. Conceol them in long gross,





LEGEND:
1-2-3 ETC. INDICATES ORDER OF STRINGING WIRE

NOTE:
EYES POINT IN DIRECTION FROM
WHICH FENCE IS BEING ERECTED

Figure 76. Low wire fence.

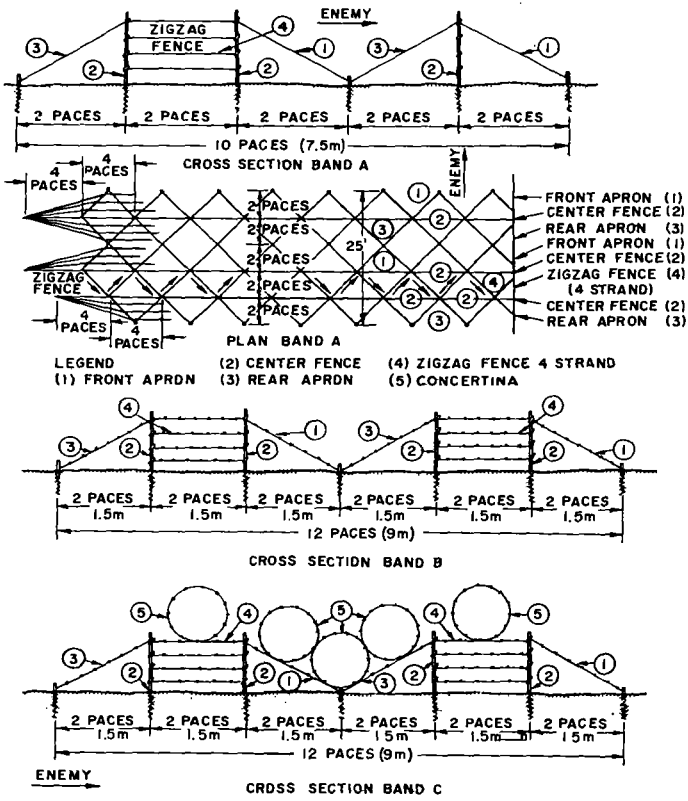


Figure 77. Combination bands of wire obstacles.

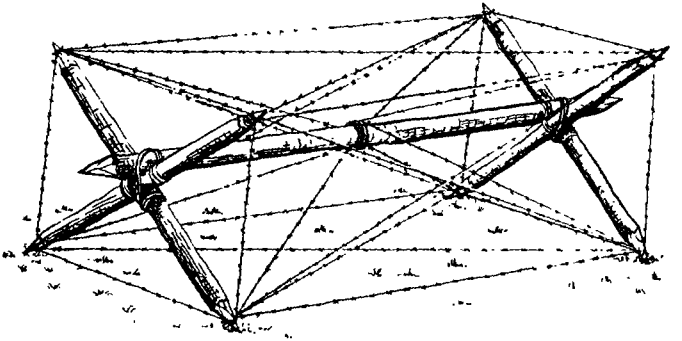


Figure 78. Knife rest.

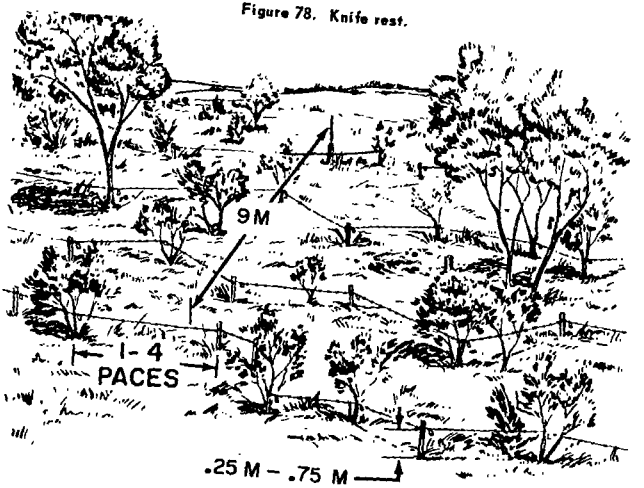


Figure 79. Tanglefoot.

an the side at a path, ar at the edge ot a field. Ploce them in depth In an Irregular pattern.

(4) Tanglefoot Is used where cancealment is needed (fig. 79). Use it In a minimum depth af 9 meters. Place pickets at Irregular Intervals af fram .75 ta 3 meters. Height af the barbed wire varies fram .25 ta .75 meters. SIte this wire in scrub, If possible. Use bushes as supports far port of the wire and shart pickets in apen graund.

(5) The trestle apran fence (fig. 80) has Inclined crosspieces spaced at 4.8-6-meter intervals ta carry wires an the enemy side.

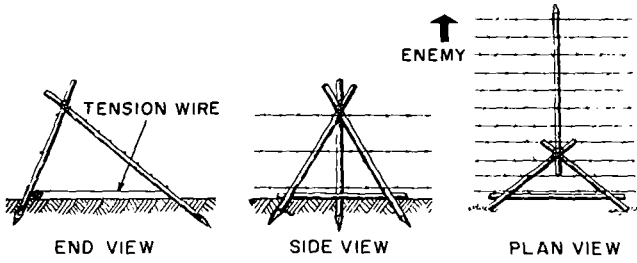


Figure 80. Trestle apran fence.

CHAPTER 5

BRIDGING

Section I. Marking of Bridges and Vehicles

47. MARKING OF BRIDGES

a. Classification.

(1) The class number of a bridge represents the safe load-carrying capacity of a single-lane bridge, or the single lane of a multilane bridge under normal crossing conditions. The bridge class number may be a single class number, which will permit either a wheeled or tracked vehicle to cross if the vehicle class number is equal to or less than the bridge class number. The bridge class number may be a dual class number, which indicates one normal class number for wheeled vehicles and another normal class number for tracked vehicles. Dual classification may be used for bridges with a capacity greater than Class 30. Dual class numbers are written (70)/50, (80)/60, (50)/70, and so on, with the wheeled class number always in parenthesis above the tracked vehicles class number.

(2) The normal class number is the largest bridge class number (single or dual) which permits the normal crossing of vehicles whose vehicle class numbers are equal to or less than the bridge class number.

(3) A special class number represents the load-carrying capacity of a bridge under special crossing conditions. These numbers are not posted on standard bridge marking signs, but on supplementary signs.

(4) Width requirements. See table 30.

Table 30. Bridge Width Requirements

Bridge class	4 - 12	13 - 30	31 - 60	61 - 100
One-lane width	9'0"	11'0"	13'2"	14'9"
Two-lane width	18'0"	18'0"	24'0"	27'0"

b. Bridge Signs.

(1) For prefabricated bridges and ferries, bridge signs indicate the class number given in several technical manuals. For bridges fixed in place or for nonstandard fixed bridges designed in the field, bridge signs shall indicate the class number.

(2) All single-lane bridge signs are a minimum of 16 inches in diameter. For multilane and dual class bridges, the signs are at least 20 inches in diam-

eter. Numerals are black on a yellow background, with a black border 1½ inches wide (fig. 81).

(3) A multilane bridge has a roadway wide enough to carry at least two lanes of traffic simultaneously. If each lane has the same class, the signs are the same as for single-lane bridges. If the lanes are of different classes, each lane has a class sign (fig. 82). Two-lane bridges may carry a combi-

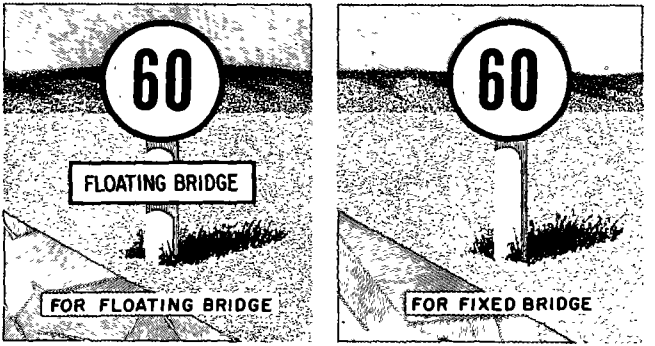


Figure 81. Typical bridge signs.

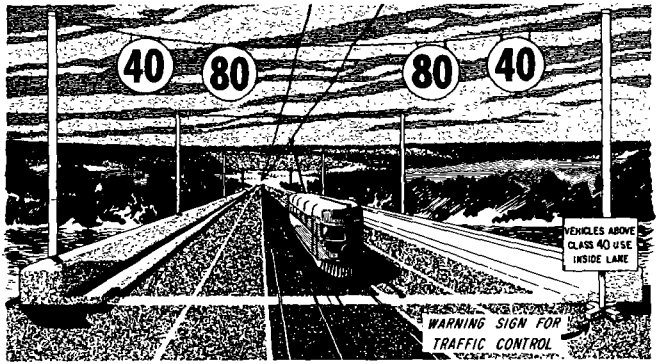


Figure 82. Multilane bridge sign.

nation circular sign (fig. 83), which gives the normal two-way classification on the left and the computed, one-way classification on the right.

(4) Dual classification is used for bridges with a capacity greater than class 30. Two numbers are then shown on the sign: the upper one for wheeled vehicles, and the lower one for tracked vehicles (fig. 83). Dual-class two-lane bridges may carry a combination of dual class and combination circular class signs (fig. 84).

c. *Traffic Control.* To expedite passage of vehicles and to prevent damage to the bridge, rigid control of bridge traffic must be maintained. This is done by the following control measures:

(1) A traffic park is set up where vehicles can be halted and dispersed so as to avoid congestion.

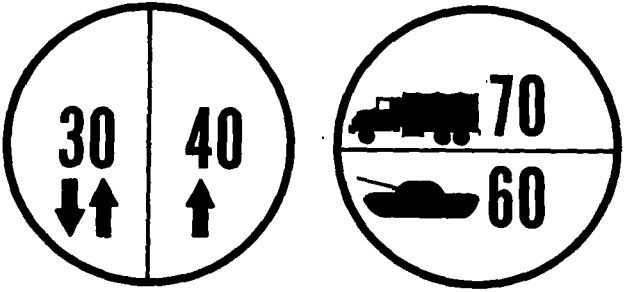


Figure 83. Typical bridge class signs.

(2) A turnout is an area used for vehicles to turn off the road and out of the line of traffic. It is meant primarily for vehicles having mechanical troubles, but it can be used as a limited traffic park.

(3) Telltales are provided for bridges having overhead framing, trolley wires, or other features which limit overhead clearance (fig. 85).

(4) A normal crossing is defined as one in which the vehicle class number is equal to or less than the bridge classification number, where vehicles maintain 30-yard gaps, and where speed is restricted to 25 miles per hour and sudden stopping or acceleration is forbidden on floating bridges.

(5) Special crossings are authorized by the theater commander or local civil authorities under exceptional operating conditions in the field to permit a vehicle to cross a bridge, or other crossing means, whose class number is

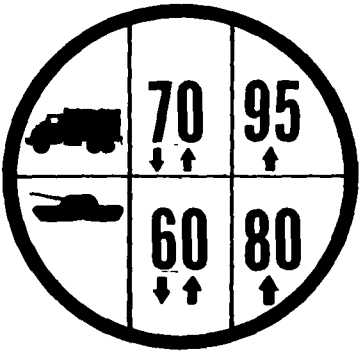


Figure 84. Typical combination of dual class and two-lane bridge class signs.

less than that of the vehicle. Special crossings are either caution crossings or risk crossings.

(a) A caution crossing of a bridge is permitted where vehicles with a classification up to 25 percent above the capacity of the nonstandard bridge or the published caution class of a standard bridge can proceed under strict traffic control. For standard prefabricated military bridges, refer to the published caution class in the appropriate bridge technical manual. Caution crossings apply to single lane bridges and multilane bridges when the vehicle remains on the centerline, maintain a 50-yard distance from the vehicles in front, does not exceed 8 miles per hour, does not stop, is not accelerated, and does not have its gears shifted on the bridge.

(b) A risk crossing may be made only on prefabricated fixed and floating bridges. Risk crossings are made only in the gravest emergencies. The vehicle moves on the centerline, does not exceed 3 miles per hour, is the only vehicle on the bridge, does not stop, is not accelerated, and stays in low gear. The vehicle class number must not exceed the published risk class. After the crossing, and before other traffic is permitted, the engineer officer should reinspect.

48. MARKING OF VEHICLES

a. **Weight Classification.** All vehicles with a gross weight over 3 tons and all trailers with a rated payload over 1½ tons are assigned classification numbers. Those

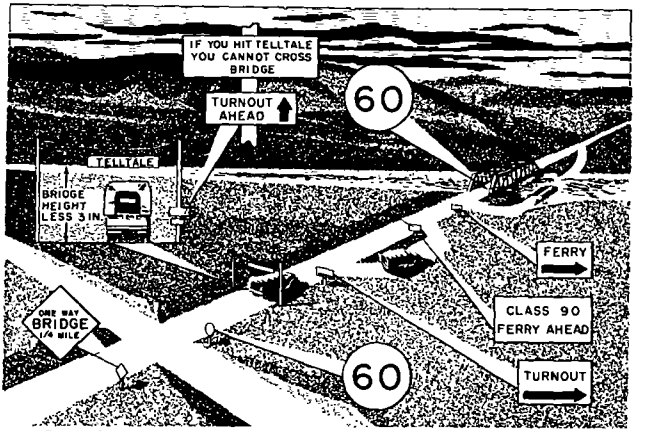


Figure 85. Example of telltale, turnout, and sign arrangement for single-lane bridges.

numbers indicate a relationship between the load carrying capacity of a bridge and the effect produced on it by a vehicle (fig. 86). The effect of a vehicle on a bridge depends upon the gross weight of the vehicle, the weight distribution to the axles, and the speed at which the vehicle crosses the bridge.

b. Vehicle Signs.

(1) Classification numbers assigned to vehicles are whole numbers ranging from 4 through 150. Front signs on a vehicle are 9 inches in diameter and the side signs are 6 inches in diameter. The signs have black numerals on a yellow background, and the numerals are as large as the sign will permit (fig. 87). Place the front sign above the bumper to the driver's right and below his line of vision; and the door sign on the right side of the vehicle in a place where normal use of the vehicle does not conceal it from view.

(2) With a combination vehicle (two or more single vehicles spaced less than 30 yards apart), the front sign shows the normal vehicle class for the combination with the letter "C" in red above the class number. Each vehicle in the combination carries a side sign which shows its class as a single vehicle.

(3) If one vehicle is towing another, they are considered separate. However,

EFFECT OF VEHICLE ON BRIDGE
DEPENDS ON:

1. GROSS WEIGHT OF VEHICLE
2. WEIGHT DISTRIBUTION TO AXLES
3. SPEED AT WHICH VEHICLE CROSSES BRIDGE

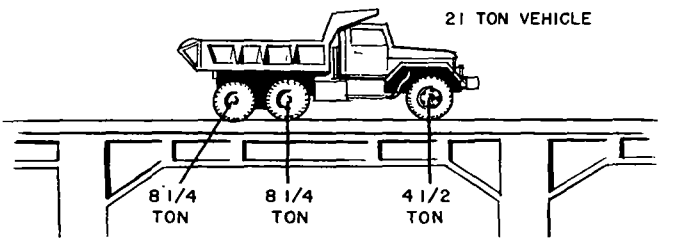


Figure 86. Effect of vehicle on bridge.

Figure 87. Typical vehicle sign.

if they ore both on the same span and the distance between them is less than 30 yards, they are considered as a combination vehicle with a temporary front sign showing the class number. If the class numbers of the two vehicles add to less than 60, use the formula 9/10 (A & B) where A is class of first vehicle, and B the class of the second. If the class numbers add to more than 60, add A & B.

49. OIMENSIONS, WEIGHTS, ANO CLASSIFICATION OF VEHICLES

(For information on these factors, see FM 5-36 ond FM 55-15.)

Sectian II. Design and Classification

50. NOMENCLATURE

The types of stream-crossing methods found in place ar normally constructed in o theater of operatians are described in this section. The existing bridges found in developed areas vary in size and complexity from simple wood trestle and stringer bridges to multispan arch or suspension bridges. Thase normally constructed in a theater af operations include floating bridges, rafts, fixed bridges assembled from floating equipment, ond panel bridges. (For tabulated data on the use ond capacities af light stream-crossing equipment, see table 115, paragraph 135.)

a. **Floating Bridges.**

(1) The oluminum footbridge is the standord means of crossing foot troops. This footbridge setfurnishes 472 feet 6 inches of bridge, and can be used in currentsup to 11 feet per second.

(2) The M4 floating bridge (fig. 88) has a capacity of class 60 in currents up to 5 feet per secand. The deck consists af hollow oluminum balk. With an 18-balk roadway, the deck is 166½ inches wide. The flaating support is provided by joining two aluminum half pantans stern to stern.

(3) The class 60 floating bridge has o copocity of closs 65 in currents up to 5 feet per secand. The deck consists of two steel deck-tread panels and one filler ponel. This provides o raodway width of 162 inches. The flaating support consists of two pneumatic half floats, jained stern ta stern.

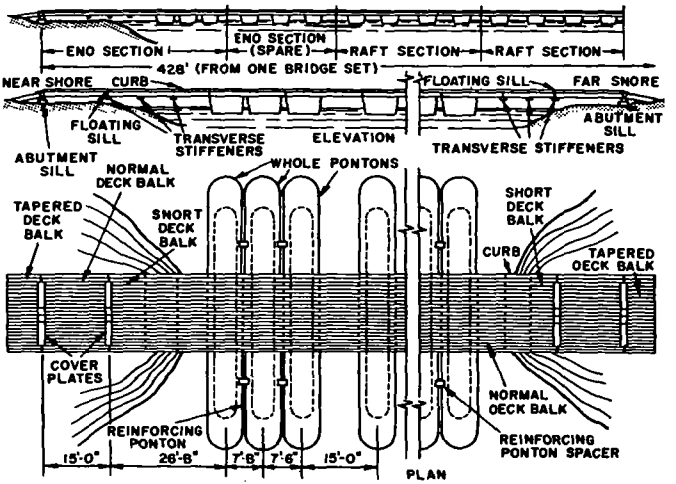


Figure 88. Floating bridge, M4.

(4) The M4T6 bridge is a manpower-assembled bridge for a rapid means of stream crossing for military vehicles up to class 55 in currents up to 5 fps. It has a continuous roadway of hollow aluminum alloy deck bulk 166 ½ inches between curbs and this roadway is identical with that of the M4 bridge. The deck bulk of the M4 was adapted to the floating support of the class 60 by the use of saddle adapters and bulk connecting stiffeners. This bridge is hand erectable.

(5) The light tactical raft floating bridge is assembled from the light tactical raft equipment. Both raft and bridge consist of a deck built of aluminum sections supported on aluminum pontons.

(6) Anchorages must be provided to secure the bridge between the abutments and to insure continued alinement. The selection of an anchorage system is influenced by the width of the river, velocity, turbulence, variations in stage, debris flow, nature of material in the river bed and embankments, and the time, materials, and personnel available. The anchorage system is designed to withstand the worst conditions anticipated. The basic anchorage systems used are: overhead cable bridle-line system, shore guys, and bed anchors. The most satisfactory method of anchoring a floating bridge is the overhead cable bridle-line system supplemented by shore guys. Float-supported cables, shore guys, and bed anchors should not be used as the final anchorage system except when it is not possible to install an overhead cable system. Although combinations of the basic anchorage systems may be used during assembly and for reinforcement, the load cannot be properly divided between two systems; one system must supplement the other (fig. 89).

b. Rafts.

(1) The light tactical raft is usually a 4-pontoon raft consisting of 2 end panels, the ramp panels, the articulator assembly, and 3 bays of decking supported on 4 aluminum pontons. The loading space width from curb to curb is 108 inches, and the loading length is approximately 29½ feet.

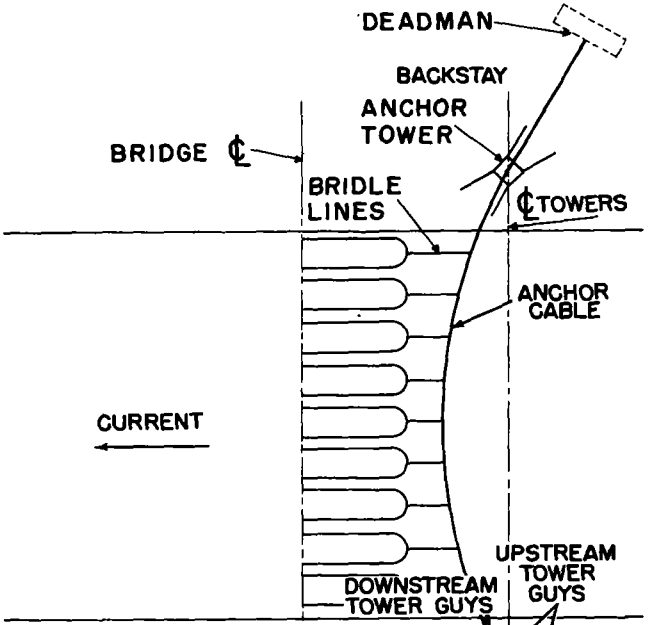
(2) The M4 raft (fig. 90) can be assembled from the components of the M4 floating bridge set (a(2) above).

(3) The class 60 raft (fig. 91) can be assembled from the components of the class 60 floating bridge set (a(3) above).

(4) The M4T6 raft (fig. 92) can be assembled from components of the M4T6 floating bridge set (a(4) above).

c. **Fixed Bridges Assembled from Floating Equipment.**

(1) The deck-bulk fixed bridge (fig. 93) is a means for heavy vehicles to cross gaps. The deck bulk from the M4T6 floating bridge set (a(4) above) can be used. This bridge has a roadway of deck bulk laid as a single span or multiple span between trestles or expedient piers.



OFFSET OF DEADMEN

Current Velocities		Final Horizontal Cable Sag (in percent)	Offset Angle (ϕ) (in degrees)	Offset Upstream (in feet per hundred from tower base)
Normal Assembly	Reinforced Assembly			
3 fps	——	3	5	9
5 fps	3 fps	4	6.5	11
7 fps	4 fps	5	8	14
9 fps	7 fps	6	9.5	17
11 fps	9 fps	7	11	19
——	11 fps	8	13	23

Figure 89. Typical anchor cable system.

(2) The superstructure of the class 60 floating bridge may be used to bridge gaps. Single span fixed bridges up to 60 feet in length (fig. 95) can be assembled from it or trestles employed for multiple spans.

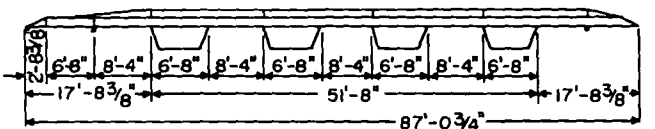
d. Panel Bridges.

(1) The M2 panel bridge, Bailey type (fig. 94), provides a rapid means of bridging streams and ravines for all military loads. It can be assembled in different ways for various spans and classes. It is a through-truss bridge supported by two main trusses formed from 10-foot steel truss sections called panels.

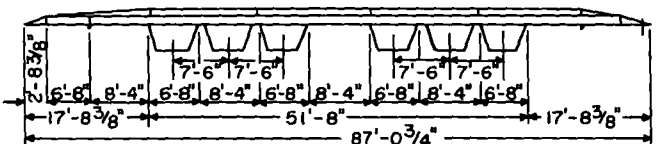
(2) Each bridge set has 126 panels (weighing 577 pounds each), 56 transoms (618 pounds each), 96 stringers (260 to 267 pounds each), and 48 ribands (215 pounds each).

e. Stringer Bridges.

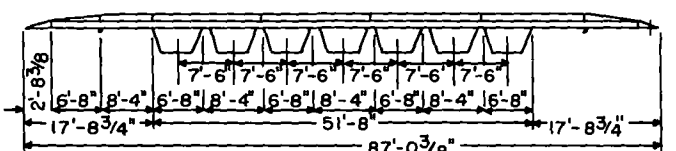
(1) A timber trestle bridge is one of the simplest types of bridges built in a theater of operations. Spans are usually limited to 25 feet using timber stringers. The stringers rest on abutments and trestle bents as shown in figure 97. Its components are listed in table 32, with numbers corresponding to those in figures 97 and 99.



(1) 4 PONTON
(NORMAL CONSTRUCTION)
NOTE: PONTONS ON 15' CENTERS

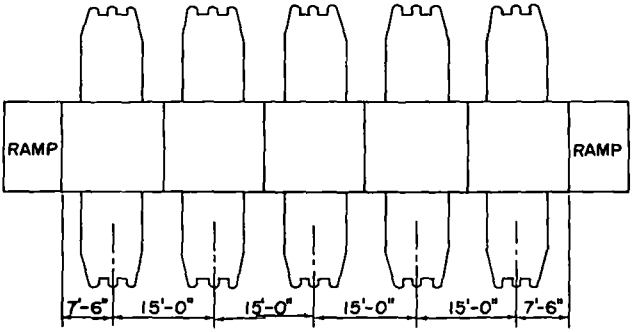


(2) 6 PONTON
(REINFORCED CONSTRUCTION)
NOTE: PONTONS ON 7'-6" CENTERS

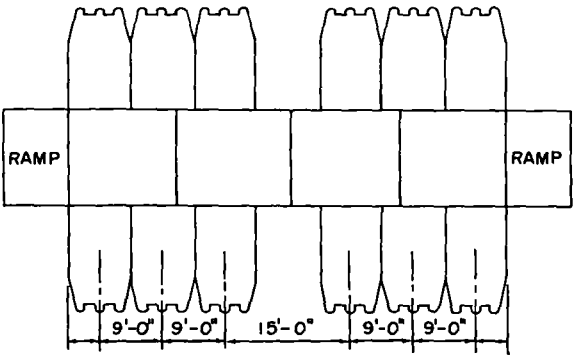


(3) 7 PONTON
REINFORCED CONSTRUCTION
NOTE: PONTONS ON 7'-6 CENTERS

Figure 90. M4 raft.



NORMAL 5-FLOAT RAFT



REINFORCED 6-FLOAT RAFT WITH FOUR NORMAL DECK BAYS

Figure 91. Class 60 raft.

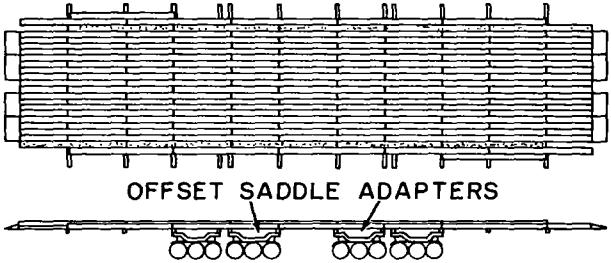


Figure 92. M4T6 bridge reinforced end section.

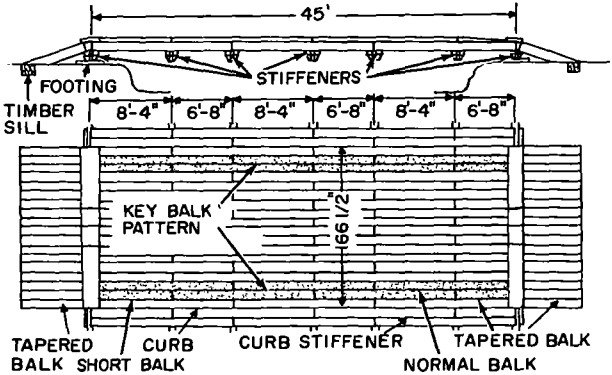


Figure 93. Layout of deck-balk fixed bridge.

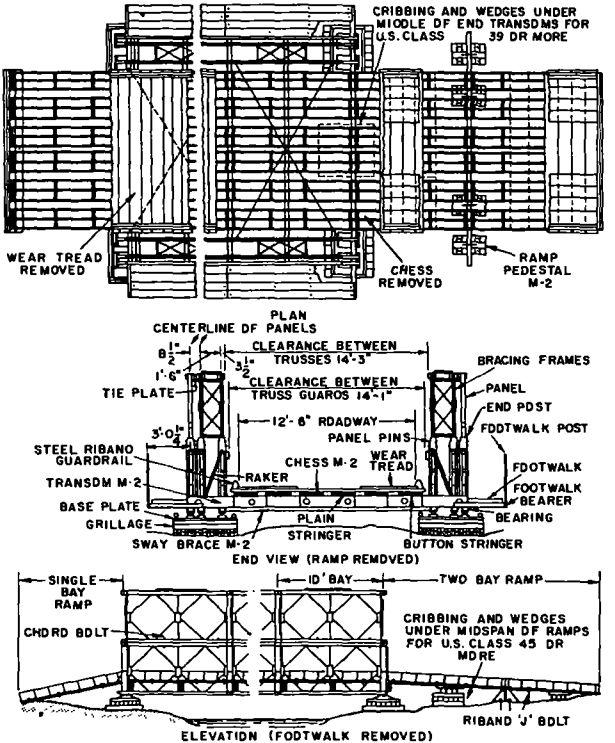


Figure 94. Steel panel fixed bridge, Bailey type, M2.

Toble 31. Classes of Fixed Span Assemblies Shown in Figure 95

Clear Span (ft)	Type of Assembly	Classes		Clear Span (ft)	Type of Assembly	Classes	
24	ABCDE	N	(120)* 100	30	ABCD	C	(110) 65
		C	(120)* 100*			R	(120)* 90
		R	(120)* 100		E	N	(110) 70
26	ABCD	N	(120)* 95			C	(120) 80
		C	(120)* 100			R	(120)* 95
		R	(120)* 100	32	BCDE	N	(95) 60
	E	N	(120)* 100			C	(105) 70
		C	(120)* 100			R	(120) 85
		R	(120)* 100	34	BCDE	N	(85) 55
28	ABCD	N	(115) 80			C	(90) 63
		C	(120)* 87			R	(110) 75
		R	(120)* 100	36	BCDE	N	(75) 50
	E	N	(120) 85			C	(81) 58
		C	(120)* 92			R	(110) 68
		R	(120)* 100		CDE	N	(65) 45
30	ABCD	N	(100) 65			C	(75) 53
						R	(90) 65

*Limited by roadway widths.

Table 31. Continued

Clear Span (ft)	Type of Assembly	Classes	
40	CDE	N	(60) 40
		C	(68) 50
		R	(83) 60
50	CDE	N	(30) 30
		C	(36) 36
		R	(50) 45
60	CDE	N	(20) 22
		C	(22) 25
		R	(28) 30

Notes

1. Figures in parentheses represent wheeled vehicle class and other figures represent tracked vehicle class.
2. These capacities are for most critical position of abutments.
3. For symmetrical erection of type B with respect to abutments, the stated capacities may be increased to 10 tons.
4. Number of normal deck panels utilized depends on span length desired.

(2) The pile bent bridge uses piles because of conditions which prevent the use of timber trestle bents. Deep water, swift current, or other footing conditions demand the use of piles (fig. 100).

(3) The load carrying component of the superstructure is the stringer system, which may be rectangular timber, round timber, or steel beams. Steel stringers are either I-beams, wide-flange beams, channel beams, or built-up beams. Maximum span will depend on the size beam and capacity required.

f. Concrete and Masonry Arch Bridges.

(1) In the concrete slab bridge, a reinforced concrete slab extends between the supports (fig. 101). The slab is usually supported by concrete abutments and piers. It is seldom in spans of over 20 feet.

(2) The concrete arch bridge has the load-bearing members arched. The masonry arch bridge is set up in the same design.

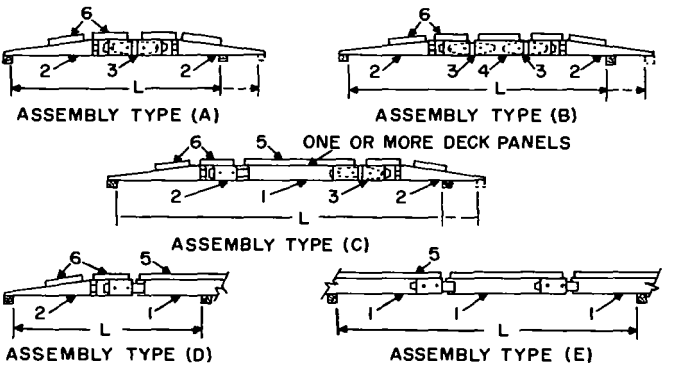


Figure 95. Class 60 fixed bridge.

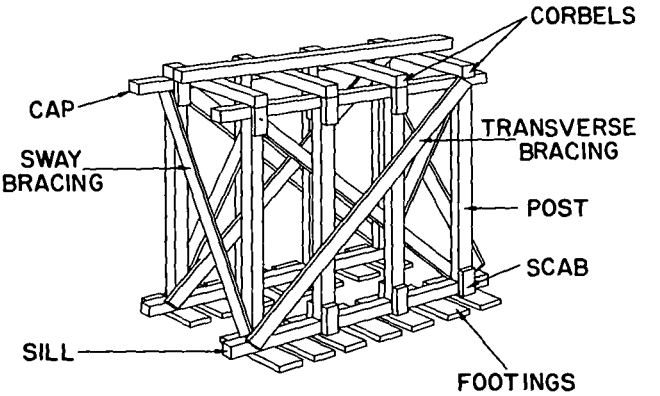


Figure 96. Timber trestle pier.

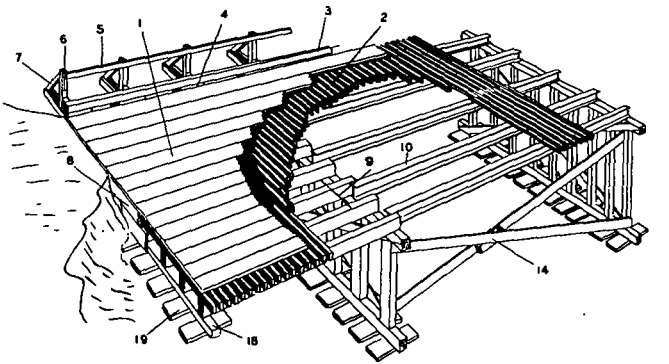


Figure 97. Timber trestle bridge.

Table 32. Bridge Components of Timber Trestle Bridge*

No.	Bridge Components	Common Sizes or Reference
1	Tread	See figure 97
2	Open-laminated deck	See figure 97
3	Curb	6" x 6", figures 97 and 98
4	Curb riser block	See figures 97 and 98
5	Handrail	See figures 97 and 98
6	Handrail post	See figures 97 and 98
7	Handrail kneebrace	2" x 4", figures 97 and 98
8	End dam	Use tread material
9	Timber stringers	See paragraph 51g
10	Steel stringers	See paragraph 51h
11	Cap	See figures 99 and 100
12	Posts	See figure 99
13	Transverse bracing	2" x 10" or 3" x 8", figure 99
14	Longitudinal bracing	4" x 6" or 3" x 8", figure 97
15	Scabs	Use tread material
16	Sill	See figure 99
17	Footings	See figure 99
18	Abutment sill	See figure 97
19	Abutment footings	See figure 97

*See figures 97 and 99.

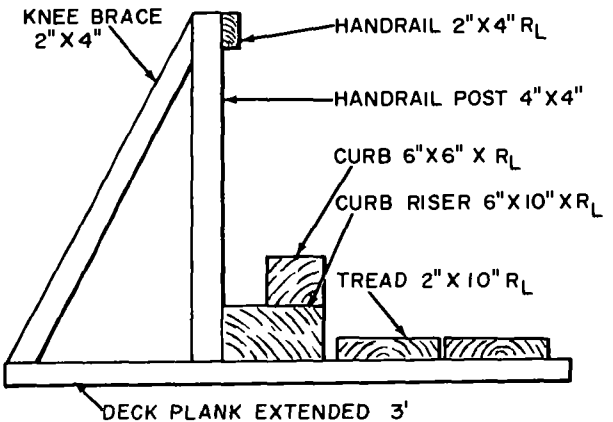


Figure 98. Curb and handrail system (minimum specifications).

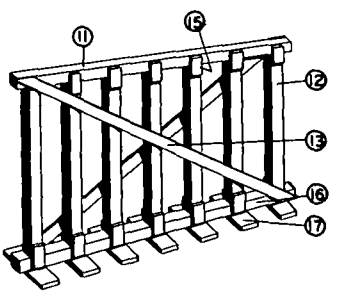


Figure 99. Typical timber trestle bent.

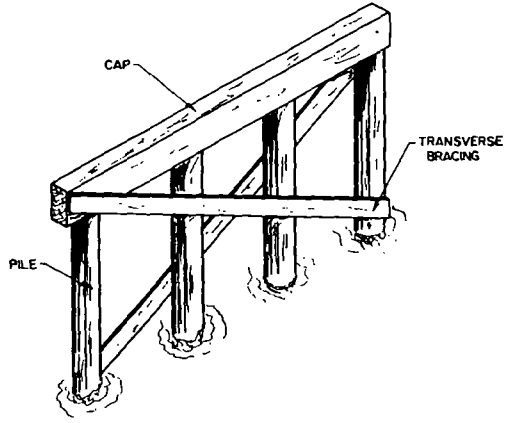


Figure 100. Pile bent.

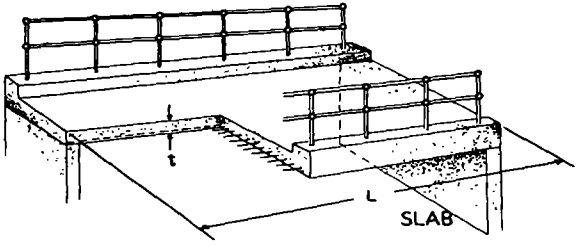


Figure 101. Concrete slab bridge.

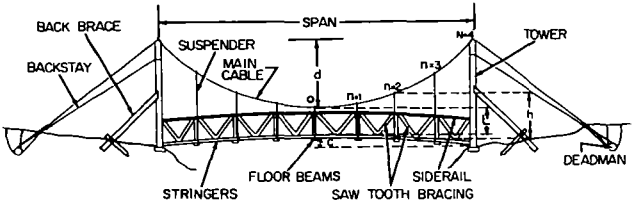


Figure 102. Light suspension bridge.

g. Light Suspension Bridge. The suspension bridge (fig. 102) is used for long spans high above the water. The floor system is suspended from cables, which are supported on towers and anchored to abutments.

h. Armored Vehicle Launched Bridge.

(1) This bridge is a class 60 bridge which is designed to be transported, launched, and retrieved by a modified turretless medium tank. The bridge is designed to fold at midspan and to be transported on top of the launcher

by means of a launching mechanism and carrying rack. It is conventional, girder type bridge of aluminum alloy and may be launched or retrieved from either end. There are eight main sections together with necessary bracing, diaphragms, and pins. Its length, while being transported, is 31 feet 6 inches; when unfolded, it is 63 feet.

(2) The armored vehicle launched bridge has a clear span of 60 feet. Each clear treadway width is 4 feet 11 inches, and a single treadway will cross a ¼-ton vehicle. With both treadways, larger vehicles (including medium tanks) can cross this bridge. The usable tread width is 12 feet 6 inches; the overall width is 13 feet 2 inches.

i. **Amphibious Mobile Assault Floating Bridge.**

(1) This amphibious river-crossing equipment consists of these major items (fig. 103).

(a) The amphibious bridge vehicle, class 60 (ABV-60).
(b) The amphibious ramp vehicle, class 60 (ARV-60).

(2) The basic unit of all three amphibious vehicles is a welded steel-plate, water-tight hull approximately 39 feet in length, mounted on a four-wheel drive chassis.

(3) To insure stability and buoyancy during navigation, each vehicle is equipped with two pneumatic floats about 39 feet in length and 4½ feet in diameter, attached to the sides. A compressor is kept in operation during water travel to maintain a constant pressure on the floats.

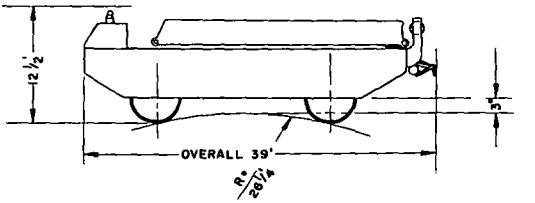
(4) An integral part of each ABV-60 is 26' 3" of decking folded for road transport, and pivoted and widened for bridge construction. After entering the water, the deck section is rotated 90 degrees, widened to 13' 2", and deck-filler panels are added.

(5) The effective length of the ramp of the ARV-60 is 26' 3" long, and 13' 2" wide.

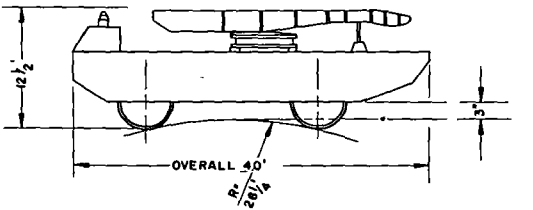
51. ESTIMATING CAPACITIES

a. **Floating Bridges.** See table 33.

b. **Rafts.** See table 34.



AMPHIBIOUS BRIDGE VEHICLE CL60



AMPHIBIOUS RAMP VEHICLE CL60

Figure 103. Amphibious mobile assault floating bridge.

Table 33. Continued

Type of bridge	Transportation required[5]	Type of crossing	Stream velocities in feet per second for specified assembly[11]					
			Normal					
			3	5	7	8	9	11
M4T6[3]	Two 2½-ton 6 x 6 cargo trucks, or one 5-ton bridge truck per bay	Normal[7]	$(50)_{55}$	$(45)_{55}$	$(40)_{50}$	$(35)_{45}$	$(30)_{40}$	$(25)_{30}$
		Caution[8]	$(60)_{61}$	$(58)_{59}$	$(54)_{55}$	$(49)_{51}$	$(45)_{47}$	$(35)_{37}$
		Risk[9]	$(68)_{69}$	$(66)_{67}$	$(62)_{63}$	$(59)_{60}$	$(54)_{56}$	$(43)_{45}$
Light tocticol raft floating bridge	———	Normal	16	16	13	11	8	2
		Caution	18	18	15	12	9	3
		Risk	21	21	17	14	11	5

[1]Based upon abutment deck level within 10 inches of floating bridge deck level, except for hinged or other special end spans. Where limitations are exceeded, capacities must be reduced.

[2]Reinforced by placing 3 floating supports under 2 bays of decking. 50 percent reinforced.

[3]Capacities based on roadway widths of 18 bulk and dock width of 22 bulk. Reinforced assembly requires a 38'4" superimposed end span.

[4]Reinforced bridge capacities up to 9 fps are controlled by end span limitations.

[5]Transportation for bridge equipment only. Additional needed for any construction equipment required and for troops.

[6]Average for trained troops and continuous daylight assembly. Allowances are required for specific situations.

Table 33. Classes of Floating Bridges[1]

Type of bridge	Transportation required[5]	Type of crossing	Stream velocities in feet per second for specified assembly[11]					
			Normal					
			3	5	7	8	9	11
Aluminum footbridge	Two 2½-ton, 6 x 6 cargo trucks w/2 pole tlrs, or three 2½-ton trucks	Normal						
		Caution		Safe –	–	–	–	–
		Risk						
M4[3]	One 2½-ton lwb bolster truck per 15 ft. of bridge	Normal[7]	60	60	$(45)^{12}_{50}$	$(45)_{45}$	$(30)_{35}$	$(18)_{20}$
		Caution[8]	68	65	$(58)_{59}$	$(52)_{53}$	$(44)_{46}$	$(29)_{31}$
		Risk[9]	72	68	$(61)_{62}$	$(58)_{59}$	$(53)_{54}$	$(37)_{39}$
Class 60[4]	One 5-ton bridge truck per bay	Normal[7]	$(60)_{65}$	$(55)_{65}$	$(45)_{55}$	$(40)_{50}$	$(35)_{45}$	$(22)_{25}$
		Caution[8]	$(65)_{70}$	$(62)_{67}$	$(56)_{61}$	$(52)_{56}$	$(45)_{49}$	$(34)_{37}$
		Risk[9]	$(75)_{79}$	$(72)_{77}$	$(67)_{72}$	$(62)_{67}$	$(57)_{62}$	$(46)_{50}$

Table 33. Continued

Type of bridge	Type of crossing	Stream velocities in feet per second for specified assembly[11]						Traffic capacity and vehicular distance for safe crossings in daylight, except as otherwise noted[10]
		Reinforced[2]						
		3	5	7	8	9	11	
M4T6[3]	Normal[7]	75	75	(70) 75	(65) 70	(55) 60	(27) 30	400 vehicles per hour, see notes 7, 8, and 9.
	Caution[8]	80	80	79	73	(66) 67	(43) 45	
	Risk[9]	90	90	90	87	81	(59) 60	

[7]Vehicle anywhere on width of bridge deck. Speeds of 15 mph recommended; up to 25 mph permitted.

[8]Center of vehicle within 12 inches of bridge centerline. Maximum speed 8 mph. Vehicle spacing, 150 feet. No sudden stopping or acceleration.

[9]Center of vehicle within 9 inches of centerline and with guide. Maximum speed, 3 mph. One vehicle on bridge. No stopping, braking, or gear shifting.

[10]Traffic capacities are for all moving forward and rearward.

[11]Use 2-space distance for 3 fps only; 1-bay distance for 4 and 5 fps; 2-bay distance for 6 and 7 fps.

[12]Wheeled vehicle classification (40) Tracked vehicle classification 50. Single classification indicates both classifications are the same.

Table 33. Continued

Type of bridge	Type of crossing	Stream velocities in feet per second for specified assembly[11]						Traffic capacity and vehicular distance for safe crossings in daylight, except as otherwise noted [10]
		Reinforced[2]						
		3	5	7	8	9	11	
Aluminum footbridge	Normal							Day: 75 men per minute. Night: 40 men per minute at 2-pace distance. Blockout: 25 men per minute.
	Caution		Safe	– – –	– –	– –	– –	
	Risk							
M4[3]	Normal[7]	95	95	(75) 80	(60) 65	(45) 50	(24) 27	400 vehicles per hour; see notes 7, 8, and 9.
	Caution[8]	100	(100) 99	(88) 85	(75) 74	62	(35) 37	
	Risk[9]	(105) 100	(105) 100	(101) 96	(88) 85	(74) 73	(45) 46	
Class 60[4]	Normal[7]	65	65	65	65	65	(30) 35	400 vehicles per hour, see notes 7, 8, and 9.
	Caution[8]	75	75	75	75	75	(47) 51	
	Risk[9]	85	85	85	85	85	(70) 74	

Table 34. Continued

Type of raft	No. of pontons or floats	Length		Operating crew	Type of crossing	Class of raft and no. of power units needed[2]				Type of power unit required
		Overall, including ramps	Available for loading[1]			Stream Velocity, fps*				
						5	7	9	11	
Class 60	5, normal	107'–5"	66'–0"	1 sqd---	Normal	(50)[1] 55	(50)[2] 55	(40)[4] 45	(30)[5] 35	27-ft bridge erection boats.[3]
					Risk	(60)[1] 65	(60)[2] 65	(50)[4] 55	(40)[5] 45	
	5, reinforced	92'–5"	54'–6"		Normal	(55)[1] 60	(55)[2] 60	(45)[4] 50	(35)[5] 40	
					Risk	(60)[1] 70	(60)[2] 65	(55)[4] 60	(45)[5] 50	
	5, with one short deck boy reinforced	83'–1"	43'–9"	11 men and necessary boat operation	Normal	(60)[1] 65	(60)[2] 65	(50)[4] 55	(45)[5] 50	
					Risk	(70)[1] 75	(70)[2] 75	(60)[4] 65	(55)[5] 60	
	6, reinforced	92'–5"	57'–0"		Normal	(65)[1] 75	(65)[2] 75	(60)[4] 65	(50)[5] 55	
					Risk	(80)[1] 90	(80)[2] 90	(70)[4] 80	(60)[6] 70	
	6, with one short deck boy reinforced	98'–9"	50'–10"	-	Normal	(60)[1] 70	(60)[2] 70	(55)[4] 60	(45)[5] 50	
					Risk	(75)[1] 85	(75)[2] 85	(65)[4] 75	(55)[6] 65	

Table 34. Classes of Rafts

Type of raft	No. of pontons or floats	Length		Operating crew	Type of crossing	Class of raft and no. of power units needed[2]				Type of power unit required
		Overall, including ramps	Available for loading[1]			Stream Velocity, fps*				
						5	7	9	11	
M4[4,5]	4, normal	87'–0–¼	51'–8"	1 sqd----	Normal	(50)[1] 55	(50)[1] 55	(50)[2] 55	(40)[3] 45	27-ft bridge erection boats.[3]
					Risk	(55)[1] 60	(55)[1] 60	(55)[2] 60	(45)[3] 50	
	6, partially reinforced				Normal	(70)[1] 75	(70)[1] 75	(65)[2] 70	(50)[3] 55	
					Risk	(75)[1] 80	(75)[1] 80	(75)[2] 80	(55)[3] 60	
	7, fully reinforced				Normal	(85)[1] 90	(85)[1] 90	(80)[2] 85	(55)[4] 60	
					Risk	(90)[1] 95	(90)[1] 95	(90)[2] 95	(65)[4] 70	
Class 60	4, normal	92'–5"	51'–0"		Normal	(40)[1] 45	(40)[2] 45	(35)[3] 40	(25)[4] 30	
					Risk	(50)[1] 55	(50)[2] 55	(45)[3] 50	(35)[4] 40	
	4, reinforced	83'–1"	40'–0"		Normal	(45)[1] 55	(40)[2] 45	(35)[3] 40	(25)[4] 30	
					Risk	(55)[1] 60	(50)[2] 55	(45)[3] 50	(35)[4] 40	

Table 34. Continued

Type of raft	No. of pontons or floats	Length		Operating crew	Type of crossing	Class of raft and no. of power units needed[2]				Type of power unit required
		Overall, including ramps	Available for loading[1]			Stream Velocity, fps*				
						5	7	9	11	
Light tactical raft	4 pontons	58			Normal	12	12	8	0	27-ft bridge erection boats.[3]
	3 bays				Risk	14	14	12	4	
	5 pontons	80			Normal	9	9	8	3	
	5 bays				Risk	11	11	11	6	
	6 pontons	69			Normal	13	13	13	6	
	4 bays				Risk	15	15	15	10	

Operating characteristics of rafts	Stream width, ft		
	250	500	1,000
No. of round trips per hr in currents of 5 fps in daylight (reduce 50% for night or adverse conditions)	10	6	4
No. of rafts which can be used efficiently at one site	1	2	3

*Numerals in parentheses represent wheeled vehicle class; numerals without parentheses represent tracked vehicle class.

[1]Measured from outside edge to outside edge of end pontons or float saddle beams.

[2]Capacities are based on loading rafts with center of gravity of loads 6" downstream from top of raft and on properly inflated floats.

[3]One 19-foot bridge erection boat may be used in currents not over 5 fps. In currents of 5 fps and over, normally two 19-foot bridge erection boats may be substituted for one 27-foot boat.

[4]Extreme caution is required in loading and unloading vehicles weighing more than 70 tons.

[5]Roadway width consists of 18 bulk between curbs with 22 bulk overall.

Table 34. Continued

Type of raft	No. of pontons or floats	Length		Operating crew	Type of crossing	Class of raft and no. of power units needed[2]				Type of power unit required
		Overall, *including* ramps	Available for loading[1]			Stream Velocity, fps*				
						5	7	9	11	
M4T6	4, normal	87'–1"	51'–8"	1 sqd---	Normal	(45)[1] 55	(40)[1] 50	(30)[3] 40	(25)[4] 35	27-ft bridge erection boats.[3]
					Risk	(66)[1] 65	(62)[2] 60	(54)[3] 50	(43)[4] 40	
	5, reinforced	88'–9"	50'–1"		Normal	(75)[1]	(70)[2] 65	(55)[3] 60	(27)[5] 30	
					Risk	(90)[1]	(90)[2]	(81)[3]	(59)[5] 60	
AMAB	2, normal	104'			Normal	(45) 50	(40) 45	(30) 35	(13) 15	
					Risk	(55) 60	(48) 53	(40) 45	(18) 20	
	3, normal	131'–3"			Normal	(60) 65	(55) 60	(40) 45	(22) 25	
					Risk	(70) 75	(63) 68	(50) 55	(32) 35	
	4, normal	157'–6"			Normal	(60) 65	(55) 60	(45) 50	(27) 30	
					Risk	(73) 78	(67) 72	(60) 65	(35) 40	

c. Fixed Panel Bridges, Bailey Type, M2. (See table 36).

d. Fixed Bridges from Floating Bridge Sets. See table 35 and 37.

e. Armored Vehicle Launched Bridge.

(1) For a normal span up to 60 feet, the bridge has a normal rating of class 60, a caution rating of class 65, and a risk rating of class 75.

(2) This bridge has the mobility approximately that of a medium tank. With the bridge in travel position, the launcher can maintain the rate of march of both administrative and tactical moments. However, in planning a route, the added weight (class 62), width, and overhead clearance (13 feet, 1 inch) required must be considered. An escort reconnaissance vehicle should precede the launcher and bridge through built-up areas.

(3) In launching this bridge, bank conditions must support the launching vehicle and provide sufficient bearing to allow the bridge to support its rated load after launching.

f. Amphibious Mobile Assault Floating Bridge. (See table 34).

The capacities of the rafts vary from 30-50 tons, for a 2-unit rafts, to 80-110 tons for a 4-unit raft in current from 5 to 8 fps. A raft consisting of 5-ABV-60's and 2 ARV-60's can carry all vehicles (loads) currently assigned to the 7th United States Army. Approximately 3 round trips per hours during both day and night operation can be made across the Rhine River (900 feet wide).

g. Highway Bridge With Timber Stringers.

(1) Count number of stringers (N) in each lane of weakest span. (If weakest is unknown, use procedure for each span.)

(2) Measure width and depth of stringers in inches and span length in feet.

NOTE: Span length (L) measured from center to center of caps.

(3) Entering table 38 with the width (b) of the stringer and the depth (d), read "m". Determine "M" by the formula

$$M = Nm.$$

Table 35. Deck Balk Fixed Bridges (Span Capacities)

Type of Crossing	Capacity for Specified Span Lengths (feet) and Ratio of Deck/Roadway Widths[1]														
	23'4"	30'0"			38'4"				45'0"						
	22/18	22/18	22/16	24/18	22/18	22/16	24/18	26/18	20/16	22/18	22/16	24/18	24/16	26/18	26/16
Normal	[3](120)[2]/100	(85)/65	(90)/70	(90)/70	(45)/35	(50)/40	(55)/45	(65)/50	(24)/25	(24)/25	(30)/30	(30)/30	(40)/35	(40)/35	(45)/40
Caution	(120)[2]/100[2]	(100)/80	(100)/80	(105)/85	(70)/51	(70)/51	(75)/55	(82)/50	(40)/35	(46)/40	(46)/40	(51)/43	(51)/43	(56)/46	(56)/46
Risk	(120)[2]/100[2]	(110)/90	(110)/90	(115)/95	(78)/57	(78)/57	(85)/62	(90)/67	(47)/40	(54)/45	(54)/45	(60)/49	(60)/49	(66)/53	(66)/53

[1]Deck width (number of balk) ——— 22/18 ——— Roadway width (number of balk)

[2]Limited by roadway width

[3]Wheeled vehicle classification ——— (45)/50 ——— Tracked vehicle classification

Table 36. Class By Type of Construction and Type of Crossing Posting Classificotion (Boiley Type, M2)

Span ft	Type of crossing	SS	DS	TS	Span ft	Type of crossing	SS	DS	TS
30	N[1]	(30)[2] 30[2]			70	N	(20)	(60) 60	
	C[1]	(42) 37				C	(24)	(68) 69	
	R[1]	(47) 42				R	(30) 30	(78) 75	
40	N	(24)[4]			80	N	(16)	(50) 55	(85)[3] 80
	C	(36) 34				C	(20)	(60) 60	(95) 90
	R	(40) 38				R	(24)	(66) 64	(100)* 90*
50	N	24[4]	(75)[3] 70		90	N	(12)	(40) 45	(65) 65
	C	(33) 31	(83) 86			C	(16)	(50) 50	(74) 75
	R	(36) 35	(88) 84			R	(19)	(55) 55	(82) 82
60	N	(20)	(65) 65		100	N	(8)	(30) 30	(50) 55
	C	(30) 29	(77) 73			C	(12)	(37) 39	(57) 60
	R	(33) 32	(85) 79			R	(14)	(42) 44	(64) 66

Table 36. Continued

Span ft	Type of crossing	SS	DS	TS
110	N		(20)	(35) 40
	C		(30) 32	(47) 49
	R		(34) 36	(52) 54
120	N		(16)	(30) 35
	C		(23)	(38) 41
	R		(27) 30	(43) 45
130	N		(12)	(20)
	C		(18)	(31) 33
	R		(21)	(35) 38
140	N		(8)	(16)
	C		(14)	(24)
	R		(17)	(29) 31

Span ft	Type of crossing	SS	DS	TS
150	N			(12)
	C			(18)
	R			(22)
160	N			(8)
	C			(15)
	R			(17)
170	N			(4)
	C			(10)
	R			(13)

Span ft	Type of crossing	DD	TD	DT	TT
100	N	(80)[3] 80			
	C	(86) 90			
	R	(96) 90			

Table 36. Continued

Span ft	Type of crossing	DD	TD	DT	TT	Span ft	Type of crossing	DD	TD	DT	TT
110	N	(65) 70	(90)[3] 90*			150	N	(24)	(35) 45	(60) 60	
	C	(72) 76	(100)* 90*				C	(32) 35	(47) 51	(77) 85	
	R	(80) 83	(100)* 90*				R	(36) 40	(54) 58	(85) 90*	
120	N	(45) 55	(75)[3] 80[3]			160	N	(16)	(30) 35	(55) 55	(80)[3] 75
	C	(57) 61	(83) 90*				C	(25)	(37) 41	(69) 78	(100) 90*
	R	(64) 68	(91) 90*				R	(30) 33	(45) 48	(80) 89	(100)* 90*
130	N	(35) 45	(55) 60	(70) 80		170	N	(12)	(20)	(45) 50	(70) 70
	C	(47) 50	(65) 72	(80) 90*			C	(19)	(31) 34	(57) 64	(80) 90*
	R	(53) 56	(74) 80	(90) 90*			R	(24)	(36) 40	(64) 74	(90) 90*
140	N	(30) 35	(45) 55	(70) 70		180	N	(8)	(16)	(35) 45	(55) 60
	C	(39) 42	(57) 62	(80) 90*			C	(15)	(24)	(48) 53	(66) 75
	R	(44) 48	(64) 70	(88) 90*			R	(18)	(29) 32	(55) 60	(77) 87

Table 36. Continued

Span ft	Type of crossing	DD	TD	DT	TT
190	N		(12)	(30) 35	(45) 55
	C		(18)	(39) 43	(59) 66
	R		(22)	(46) 51	(68) 77
200	N			(20)	(35) 40
	C			(32) 36	(48) 52
	R			(38) 43	(55) 62
210	N			(16)	(24)
	C			(25)	(38) 43
	R			(31) 35	(46) 51

NOTES

*Limited by roadway width.

[1]N = Normal, C = Cautian, R = Risk.

[2]Upper figure represents wheel load class -- Lower figure represents tracked load class.

[3]Bridges which have a normal rating over class 70 must be constructed with double transams.

[4]Single classification is designated below class 30.

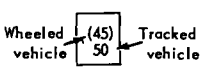


Table 37. Class 60 Fixed Bridges

Type of crossing	Capacity for specified clear span (feet)										
	24	26	28	30	32	34	36	38	40	50	60
Normal	[2](120)[1]	(120)[1]	(115)	(105)	(95)	(85)	(75)	(65)	(60)	(30)	(20)
	100[1]	95	80	65	60	55	50	45	40	30	22
Caution	(120)[1]	(120)[1]	(120)[1]	(110)	(105)	(90)	(81)	(75)	(68)	(36)	(22)
	100[1]	100	87	75	70	63	58	53	50	36	25
Risk	(120)[1]	(120)[1]	(120)[1]	(120)*	(120)	(110)	(100)	(90)	(83)	(50)	(28)
	100[1]	100[1]	100	90	85	75	68	65	60	45	30

[1]Limited by roadway width

[2]Wheeled vehicle classificatian

$\boxed{\begin{matrix}(120)\\100\end{matrix}}$ Tracked vehicle classificatian

If the stringer size is not listed, compute "M" by the formula

$$M = \frac{Nbd^2}{30}$$

(4) Mark this value of "M" an the left side of the graph in figure 104 and draw a horizontal line through this point.

(5) Draw a vertical line an the graph along span length (see bottom af graph).

(6) The intersectian af the lines drawn in steps 4 and 5 gives the bridge class based an moment. If intersectian falls between the two class curves, estimatian should be used to determine class.

(7) Entering table 38 with the width (b) af the stringer and the depth (d), read "v". Determine V by the formula

$$V = Nv.$$

If the stringer size is not listed, compute "V" by the formula

$$V = \frac{2Nbd}{45}.$$

(8) Mark this value af "V" an the left side af the graph in figure 105 and draw a horizontal line through this paint.

(9) Draw a verticol line an graph along span length.

Table 38. Properties of Timber Stringers

Actual size, in. (breadth and depth)	m**	v	Maximum span length, ft.	Actual size, in. (breadth and depth)	m**	v	Maximum span length, ft.
4 x 8	8.53	1.42	12	12 x 20	160.0	10.67	30
*4 x 10	13.33	1.78	15	12 x 22	193.6	11.73	33
*4 x 12	19.20	2.13	18	12 x 24	230.0	12.80	36
6 x 8	12.80	2.13	12	14 x 14	91.5	8.71	21
6 x 10	20.0	2.67	15	14 x 16	119.5	9.96	24
6 x 12	28.8	3.20	18	14 x 18	151.2	11.20	27
*6 x 14	39.2	3.73	21	14 x 20	186.7	12.44	30
*6 x 16	51.2	4.27	24	14 x 22	226.0	13.69	33
*6 x 18	64.8	4.80	27	14 x 24	269.0	14.93	36
8 x 8	17.07	2.84	12	16 x 16	136.5	11.38	24
8 x 10	26.7	3.56	15	16 x 18	172.8	12.80	27
8 x 12	38.4	4.27	18	16 x 20	213.0	14.22	30
8 x 14	52.3	4.98	21	16 x 24	307.0	17.07	36
8 x 16	68.3	5.69	24	18 x 18	194.4	14.40	27
*8 x 18	86.4	6.40	27	18 x 20	240.0	16.00	30
*8 x 20	106.7	7.11	30	18 x 22	290.0	17.60	33
*8 x 22	129.1	7.82	33	18 x 24	346.0	19.20	36
*8 x 24	153.6	8.53	36	8ϕ	10.05	2.51	12
10 x 10	33.3	4.44	15	9ϕ	14.31	3.18	13.5
10 x 12	48.0	5.33	18	10ϕ	19.63	3.93	15
10 x 14	65.3	6.22	21	11ϕ	26.1	4.75	16.5
10 x 16	85.3	7.11	24	12ϕ	33.9	5.65	18
10 x 18	108.0	8.00	27	13ϕ	43.1	6.64	19.5
10 x 20	133.3	8.89	30	14ϕ	53.9	7.70	21
*10 x 22	161.3	9.78	33	16ϕ	80.4	10.05	24
*10 x 24	192.0	10.67	36	18ϕ	114.5	12.72	27
12 x 12	57.6	6.40	18	20ϕ	157.1	15.71	30
12 x 14	78.4	7.47	21	22ϕ	209.0	19.00	33
12 x 16	102.4	8.53	24	24ϕ	271.0	22.6	36
12 x 18	129.6	9.60	27				

* Lateral braces required at midpoint and ends of span.

** Section modulus may be found by solving $5 = 5m$.

ϕ Diameter at butt end.

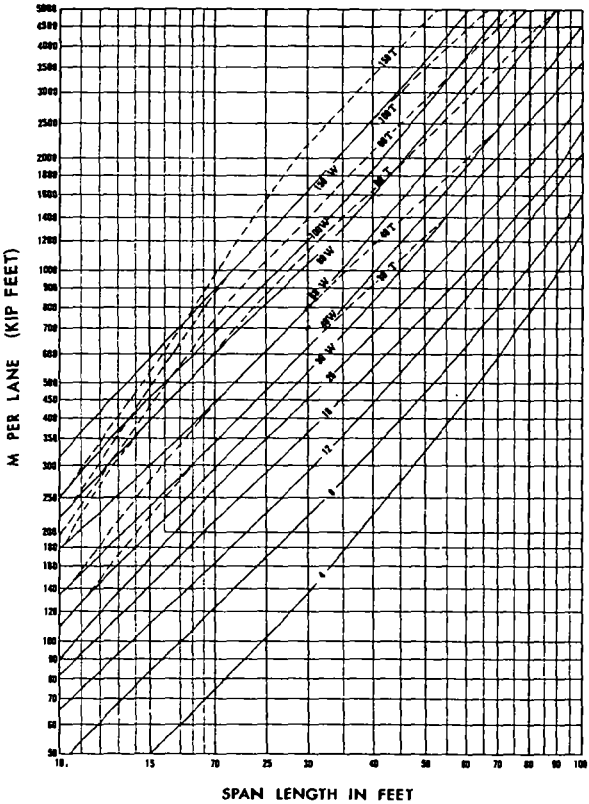


Figure 104. Bending moment.

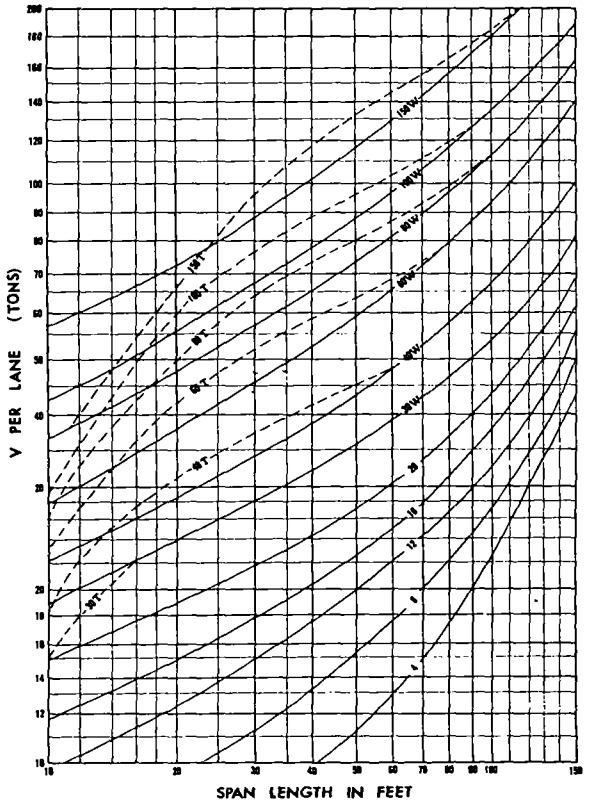


Figure 105. Shear reaction.

(10) The intersection of the lines drown in steps 8 and 9 gives the bridge class based an sheor.

(11) The lower af the closses obtained in steps 6 and 10 is the closs of the bridge.

NOTE: The class found above is the only number necessary for a one-lane bridge sign. For a two-lane bridge this is the twa-way closs number placed an the left side af the sign.

Ta determine the one-way closs number for a two-lane bridge, change steps 1 ond 2 as follaws:

(1) Caunt TOTAL number af stringers in the weokest spon. Measure width and depth of stringers, the spon length and the width af roadway.

(2) Multiply total number of stringers by $\frac{15}{\text{roadway width in feet}}$ ta obtain "N," the effective number af stringers.

(3) Steps 3 to 11. Na change.

EXAMPLE 1. Given: One-lone bridge; woad stringers; 16-ft span, 7 stringers, eoch 6" x 12" (actuol dimensions); 10-ft roadwoy width. To find bridge class: Since there is only one lone, all seven stringers are effective in that lane. Fram table 38 for b = 6" ond d = 12", reod m = 28.8. Therefore, M = 7(28.8) = 201.6. Mork this "M" on the left side of the graph in figure 104 and draw o line harizontally ta intersect the vertical 16-ft-span length line. Read class 25 fram curve. From toble 38 read v = 3.20. Therefore, V = 7(3.20) = 22.4. Mark "V" on the left side of the graph in figure 105 and drow a line horizontally to intersect the vertical 16-ft-span line. Read closs 31 wheeled and tracked from curve. Bridge is class 25, but because width is less than 11'-0, o width restriction sign must be posted (fig. 106).

h. **Design Procedure For Timber Stringers.**

(1) Moment design.

(a) Determine the value af M_R from the moment graph (fig. 104) by entering the graph with the spon length and drowing the line verticolly to the desired class curve. From there draw a line horizontally to the left and intersect the value af M_R.

(b) Determine "m" from toble 38 by entering the toble with the stringer dimensions b and d.

(c) Compute the number of stringers required per lone from the formula:

$$N_S = \frac{M_R}{m}$$

NOTE: If the stringer size is nonstandord, and "m" cannot be obtoined fram table 38, then the number af stringers per lane con be computed from the following formula:

$$N_S = \frac{30M}{bd^2} \text{ (M in K-Ft)}$$

(d) Compute the number of stringers for the total bridge width by multiplying the number per lane (step (c) above) by the number of lanes:

$$N_T = N_s \times N_L$$

(2) Shear design.

(a) If the ratio $\frac{L \times 12}{d}$ is less than 13, shear will probably be critical. If $\frac{L \times 12}{d} > 13$, then shear design should be omitted.

(b) Compute the volue of shear (V) that will occur in the span by entering the shear chart (fig. 105) with the span length and draw a line vertically to the desired class curve. From this point draw a line horizontally to the left, intersecting the value of shear (tons) occurring in a lane of the bridge.

(c) Determine the value of "v" from table 38 for the particular size of stringer being used.

(d) Compute the number of stringers required per lane from the formula:

$$N_S = \frac{V}{v}$$

NOTE: If the stringer is a nonstandard size and cannot be obtained from table 38, then compute the number of stringers from:

$$N_S = \frac{22.5V}{bd} \text{ (V in tons)}$$

(e) The total number of stringers for the entire bridge width is:

$$N_T = N_S \times N_L$$

i. **Highway Bridge With Steel Stringers.** Use same method as for timber stringers except change steps (2), (3), and (7) as follows:

(2) Measure width, depth, average flange thickness, and web-thickness of stringers in inches and span length in feet.

(3) If the stringer is a beam listed in table 39, read "m" from the table. Determine "M" by the formula

$$M = Nm.$$

If the stringer is not listed or if doubt exists, compute "M" by the formula

$$M = 2Nd_1 \left(A_f + \frac{A_w}{6}\right).$$ (See example 2).

(7) If the stringer is a beam listed in table 39, read "v" from the table. Determine "V" by the formula

$$V = Nv.$$

If the stringer is not listed or if doubt exists, compute "V" by the formula

$$V = 5Ndt_2.$$

EXAMPLE 2. Given: Two-lane bridge: steel stringers; 43-ft-span; 4 stringers, each 30¼" deep, 10½" wide flange, 1" thick flange, and 5/8" thick web; 24-ft roadway width.

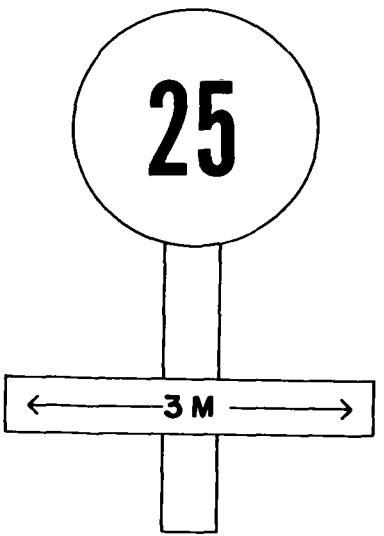


Figure 106. Bridge sign with width restriction.

Table 39. *Properties of Steel Beams*

Naminal size	Actual depth	Actual width	Flange thick-ness	Web thick-ness	m[1]	v	Max span length	Max brac-ing space
[2]518U278	51-1/4	14	1-5/8	3/4	2727	192	128	15
[3]39WF211	39-1/4	11-3/4	1-7/16	3/4	1574	147	98	15
[3]37WF206	37-1/4	11-3/4	1-7/16	3/4	1472	140	93	15
36WF300	36-3/4	16-5/8	1-11/16	15/16	2210	172	92	25.5
36WF194	36-1/2	12-1/8	1-1/4	13/16	1327	148	91	14
36WF182	36-3/8	12-1/8	1-3/16	3/4	1242	136	91	13
36WF170	36-1/8	12	1-1/8	11/16	1158	124	90	12
36WF160	36	12	1	11/16	1082	124	90	11.5
36WF230	35-7/8	16-1/2	1-1/4	3/4	1671	134	90	19.5
[2]36WF150	35-7/8	12	15/16	5/8	1006	112	90	10.5
[3]36WF201	35-3/8	11-3/4	1-3/16	3/4	1374	132	88	16
[3]33WF196	33-3/8	11-3/4	1-3/16	3/4	1274	125	83	17
33WF220	33-1/4	15-3/4	1-1/4	13/16	1481	135	83	20
33WF141	33-1/4	11-1/2	15/16	5/8	894	104	83	11
33WF130	33-1/8	11-1/2	7/8	9/16	810	93	83	10
33WF200	33	15-3/4	1-1/8	3/4	1339	124	83	18.5
[3]31WF180	31-1/2	11-3/4	1-5/16	11/16	118	108	79	16.5
30WF124	30-1/8	10-1/2	15/16	5/8	709	94	75	11
30WF116	30	10-1/2	7/8	9/16	656	84.5	75	10
30WF108	29-7/8	10-1/2	3/4	9/16	598	84	75	9
[3]30WF175	29-1/2	11-3/8	1-5/16	11/16	1028	102	74	17.5
[3]27WF171	27-1/2	11-3/4	1-5/16	11/16	942	94.5	69	18.5
27WF102	27-1/8	10	13/16	1/2	533	68	68	10
[2]27WF94	26-7/8	10	3/4	1/2	486	67	67	9
[3]26WF157	25-1/2	11-3/4	1-1/4	5/8	814	79.5	64	19
24WF94	24-1/4	9	7/8	1/2	442	60.5	61	11
24WF84	24-1/8	9	3/4	1/2	393	60	60	9.5
24WF100	24	12	3/4	1/2	498	60	60	13
24 I 120	24	8	1-1/8	13/16	502	97.5	60	12.5
24 I 106	24	7-7/8	1-1/8	5/8	469	75	60	12
24 I 80	24	7	7/8	1/2	348	60	60	8.5
24WF76	23-7/8	9	11/16	7/16	351	52	60	8.5

Table 39. Continued

Nominal size	Actual depth	Actual width	Flange thick-ness	Web thick-ness	m^1	v	Max span length	Max brac-ing space
[3]24WF153	23-5/8	11-3/4	1-1/4	5/8	736	74	59	20.5
[3]24 I 134	23-5/8	8-1/2	1-1/4	13/16	564	96	59	15
[3]22 I 75	22	7	13/16	1/2	274	55	55	8.5
[3]21WF139	21-5/8	11-3/4	1-3/16	5/8	622	67.5	54	24.5
[3]21 I 112	21-5/8	7-7/8	1-3/16	3/4	440	81	54	14.5
21WF73	21-1/4	8-1/4	3/4	1/2	301	53	53	9.5
21WF68	21-1/8	8-1/4	11/16	7/16	280	46.5	53	9
21WF62	21	8-1/4	5/8	3/8	253	39.5	53	8
20 I 85	20	7-1/8	15/16	11/16	300	69	50	11
[3]20 I 65	20	6-1/2	13/16	7/16	218	44	50	9
[3]20WF134	19-5/8	11-3/4	1-3/16	5/8	552	61.5	49	23.5
18WF60	18-1/4	7-1/2	11/16	7/16	216	40	46	9.5
[3]18 I 86	18-1/4	7	1	11/16	290	62.5	46	13
18WF55	18-1/8	7-1/2	5/8	3/8	196	34	45	8.5
[3]18 I 80	18	8	15/16	1/2	260	45	45	14
18WF50	18	7-1/2	9/16	3/8	178	34	45	8
18 I 55	18	6	11/16	1/2	177	45	45	7.5
[3]18WF122	17-3/4	11-3/4	1-1/16	9/16	576	50	44	23.5
[3]18 I 62	17-3/4	6-7/8	3/4	3/8	212	33	44	9.5
[3]18 I 77	17-3/4	6-5/8	15/16	5/8	250	55.5	44	11.5
[3]16WF112	16-3/4	11-3/4	1	9/16	400	47	42	23.5
[3]16 I 70	16-3/4	6-1/2	15/16	5/8	212	52.5	42	12
16WF50	16-1/4	7-1/8	5/8	3/8	161	30.5	41	9
16WF45	16-1/8	7	9/16	3/8	145	30	40	8
16WF64	16	8-1/2	11/16	7/16	208	35	40	12.5
16WF40	16	7	1/2	5/16	129	25	40	7.5
[3]16 I 50	16	6	11/16	7/16	138	35	40	8.5
16WF36	15-7/8	7	7/16	5/16	113	25	40	6.5
[3]16WF110	15-3/4	11-3/4	1	9/16	307	44.5	39	25
[3]16 I 62	15-3/4	6-1/8	7/8	9/16	178	44.5	39	11.5

Table 39. Continued

Nominal size	Actual depth	Actual width	Flange thickness	Web thickness	m^1	v	Max span length	Max bracing space
3 16 I 45	15-3/4	5-5/8	5/8	7/16	134	34.5	39	7.5
3 15WF103	15	11-3/4	15/16	9/16	328	42	38	24.5
3 15 I 56	15	5-7/8	13/16	1/2	154	37.5	38	10.5
15 I 43	15	5-1/2	5/8	7/16	118	33.5	38	7.5
3 14WF101	14-1/4	11-3/4	15/16	9/16	306	40	36	26
3 14 I 40	14-1/4	5-3/8	5/8	3/8	106	26.5	36	8
3 14 I 51	14-1/8	5-5/8	3/4	1/2	134	35.5	35	10
3 14 I 70	14	8	15/16	7/17	182	30.5	35	18
3 14 I 57	14	6	7/8	1/2	136	35	35	12.5
3 14 I 40	14	5-1/2	5/8	3/8	108	26	35	8
14WF34	14	6-3/4	7/16	5/16	97	22	35	7.5
14WF30	13-7/8	6-3/4	3/8	1/4	84	17.5	35	6
3 14WF92	13-3/8	11-3/4	7/8	1/2	264	33.5	33	25.5
3 14 I 46	13-3/8	5-3/8	11/16	1/2	112	33.5	33	9
3 13 I 35	13	5	5/8	3/8	76	24.5	33	8
3 13 I 41	12-5/8	5-1/8	11/16	9/16	96	35.5	32	9.5
12WF36	12-1/4	6-5/8	9/16	5/16	92	19	31	9.5
3 12 I 65	12	8	15/16	7/16	162	26	30	21
12WF27	12	6-1/2	3/8	1/4	68	15	30	7
12 I 50	12	5-1/2	11/16	11/16	101	41	30	10
12 I 32	12	5	9/16	3/8	72	22.5	30	7.5
3 12 I 34	11-1/2	4-3/4	5/8	7/16	72	25	29	8.5
3 11WF76	11	11	13/16	1/2	108	27.5	28	27
3 10 I 29	10-5/8	4-3/4	9/16	5/16	60	16.5	27	8.5
10WF25	10-1/8	5-3/4	7/16	1/4	53	12.5	25	8
3 10 I 40	10	6	11/16	3/8	82	19	25	14
10 I 35	10	5	1/2	5/8	58	31	25	8
10 I 25	10	4-5/8	1/2	5/16	49	15.5	25	7.5
10WF21	9-7/8	5-3/4	5/16	1/4	43	12.5	25	6.5
3 10WF59	9-1/2	9-1/2	11/16	7/16	118	21	24	23

Table 39. Continued

Nominal size	Actual depth	Actual width	Flange thickness	Web thickness	,m[1]	v	Max span length	Max bracing span
[3]9 I 25	9-1/2	4-1/2	1/2	3/16	46	15	24	8
[3]9 I 50	9	7	13/16	3/8	92	17	23	21
[3]8 I 35	8	6	5/8	5/16	58	12.5	20	15.5
[3]8 I 28	8	5	9/16	5/16	44	12.5	20	11.5
8WF31	8	8	7/16	5/16	55	12.5	20	14.5
[3]8WF44	7-7/8	7-7/8	5/8	3/8	72	15	20	21
[3]7WF35	7-1/8	7-1/8	9/16	3/8	52	13.5	18	18.5
[3]6WF31	6-1/4	6-1/4	9/16	3/8	40	11.5	16	18.5

LEGEND

[1]Section modulus may be found by solving $S = 1/2\,m$.

[2]Functional component beams (TM 5 - 302).

[3]These nominal sizes have no U. S. equivalent.

To find bridge class: Roadway width limits two-way class to classes 4 to 60. Number of stringers per lane = 2. Since table 39 does not list this stringer, find "M" and "V" as follows: (fig. 107).

$$M = 2Nd_1\left(A_f + \frac{A_w}{6}\right)$$

$$d_1 = d - 2t_1 = 28.25$$

$$A_f = b \times t_1 = 10.5$$

$$A_w = d_1 \times t_2 = 17.66$$

$$M = 2(2)\,(28.25)\,(10.5 + \frac{17.66}{6}) = 1519$$

$$V = 5(2)\,(30.25)(5/8) = 189$$

Two-way class: Bridge is class 60 wheeled and class 48 tracked.

One-way class: Effective No. of Str. $= \frac{15}{\text{roadway width in feet}} \times$ No. of Str.

$$= \frac{15}{24} \times 4 = 2.5$$

$$M = 2(2.5)\,(28.25)(10.5 + \frac{17.66}{6}) = 1899$$

$$V = 5(2.5)\,(30.25)(5/8) = 236$$

Bridge is class 85 wheeled and class 63 tracked.

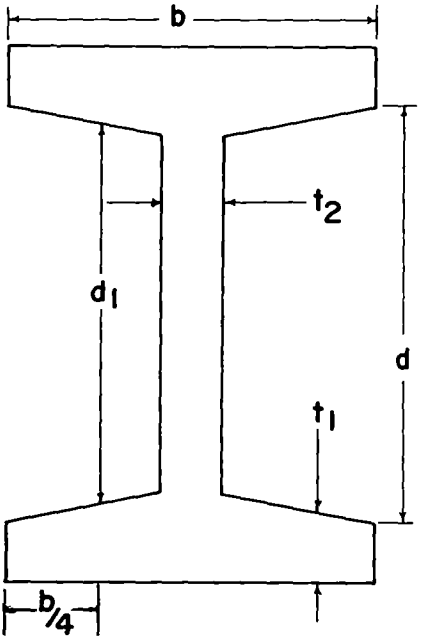


Figure 107. I-beam dimensions.

j. **Design Procedure For Steel Stringers.**

(1) Moment design.

(a) Determine the value of M_R from the moment graph (fig. 104) in the same manner as for timber stringers.

(b) Determine "m" by extracting the value from table 39. If the stringer size is not listed in table 39, then the value of "m" can be computed from the formula:

$m = 2S$ (S = section modulus), see footnote to table 39.

(c) Compute the number of stringers required per lane in the same way as for timber stringers (h(1)(c) above).

(d) The total number of stringers required for the entire bridge width is determined by multiplying the number of stringers per lane by the number of lanes in the bridge:

$$N_{ST} = N_S \times N_L$$

(2) Shear design.

(a) If the ratio $\frac{L \times 12}{d} < 10$, then shear will probably be critical rather than moment. If the ratio is equal to or greater than 10, the shear design is omitted.

(b) Determine the value of shear (V) in the span by following the procedure for timber stringers (h(2)(b) above).

(c) Determine "v" by taking the proper value from table 39 for the stringer size being used.

(d) To compute the number of stringers required, follow the procedure for timber stringers (h(2)(d) above).

NOTE: Should the stringer in question not be listed in table 39, then the number of stringers required is computed from the formula:

$$N_S = \frac{V}{5dt_w}$$, where t_w is web thickness and d is depth of beam

(e) The total number of stringers for the entire bridge is computed by multiplying the number for one lane (N_s) by the number of lanes:

$$N_{ST} = N_s \times N_1$$

k. Capacity of Trestle Bents. In almost all cases the stringer is the most critical member of the bridge (fig. 108). However, a check of the capacity of the posts may be made. To check post capacity of the weakest support:

(1) Count posts and measure size of posts.

(2) Use table 40 and determine maximum load per post.

(3) Multiply maximum load per post by number of posts. (Result is maximum load support will carry.)

(4) Add the lengths of the spans which are supported by the trestle bent.

(5) For a one-lane bridge or the one-way class of a two-lane bridge, use the values obtained in steps (3) and (4) in the graph in figure 105. to determine

the class of the trestle bent. For the two-way class of a two-lane bridge, divide the value obtained in step (3) by two and use this value in the graph in figure 105.

(6) Compare this result with the stringer class and use the smaller value as the bridge class.

$$\text{Max. Load} = \frac{A_p}{4}$$

A_p = Cross-sectional area of post (sq. in.)

I. Rules of Thumb

(1) Posts. Maximum c-to-c spacing is 5 times depth of cap or sill. C-to-c distance of outside posts equals the distance face-to-face between curbs.

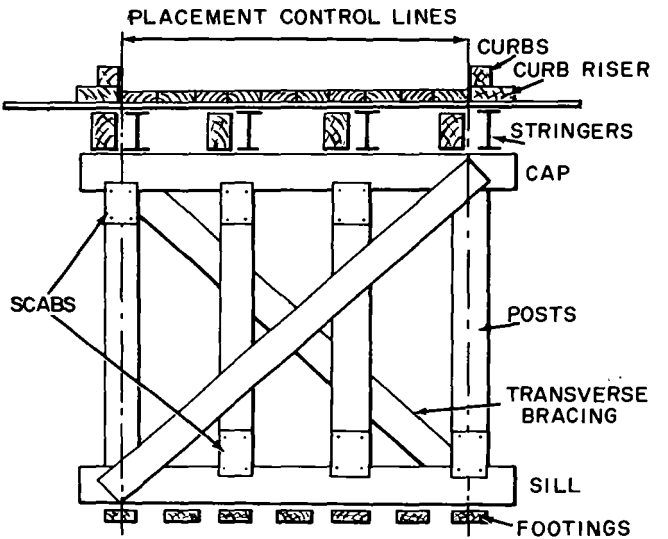


Figure 108. Placement diagram of timber trestle bent.

Maximum unsupported length of post is 30 times least dimension. The number of posts required is computed as follows (see figure 109):

$$N_{post} = \frac{V}{cap/post} \times \text{Nr. of lanes}$$

V is taken from figure 105 after computing $L_m = L_1 + L_2$. In figure 109 this would be 35 feet. By using figure 105, V would be 47 tons. The value of cap/post is taken from table 40.

Table 40. Capacities of Posts

Size of post or pile, in. Rectangular	Round	Maximum load, tons
6 x 6	7	9
6 x 8	8	12
8 x 8	9.5	16
8 x 10	10.5	20
10 x 10	11.5	25
10 x 12	12.5	30
12 x 12	14	36

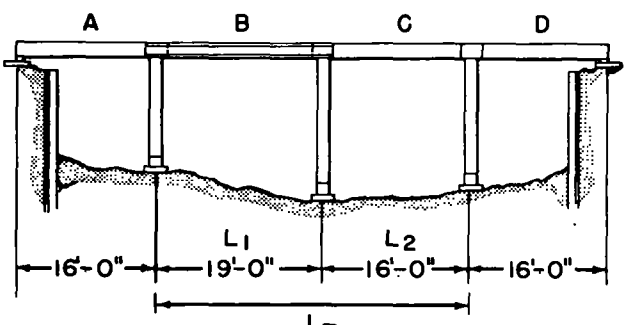


Figure 109. Bridge spans.

(2) Caps and sills. With round timber, diameter at least 2" greater than that of post. Hew timber to fit at top and joints. With rectangular timber, at least same size timber as posts with larger dimensions vertical, 6" x 8" minimum.

(3) Bracing. If bents are more than 4 feet high, use transverse cross bracing on all bents and longitudinal bracing between bents in every other span. Transverse bracing on pile bents may be omitted if pile is exposed less than 11 feet above ground line. The minimum size of bracing material is 2" x 10".

(4) Footings. Maximum length is 8 times thickness for SBC less than or equal to 4 tons per sq. ft. and 6 times thickness for SBC over 4 tons per sq. ft. (See table 41 for SBC.) There must be at least as many footings as posts.

Table 41. Soil Bearing Capacities (SBC)

Soil description	Bearing values, tons per sq ft.
Hardpan overlaying rock	12
Very compact sandy gravel	10
Loose gravel and sandy gravel, compact sand and gravelly sand, very compact sand-inorganic silt soils	6
Hard, dry consolidated clay	5
Loose coarse-to-medium sand; medium compact fine sand	4
Compact sand clay	3
Loose fine sand, medium compact sand-inorganic silt soils	2
Firm or stiff clay	1.5
Loose saturated sand-clay soils, medium soft clay	1

(5) Flooring. Minimum thickness exclusive of tread is c-to-c stringer spacing divided by 8. or 3", whichever is greater. Tread is at least 2" thick.

(6) Curb and handrail. For specification, see figure 98.

NOTE: If bridge specifications do not comply with the above rules, or if members are damaged, reinforcement and/or repair will be necessary prior to final classification.

m. **Masonry Arch Bridge Classification.** To obtain the bridge classification number for a masonry arch bridge, a provisional class number based on the crown thickness and span length is determined; this provisional class number is then adjusted by

applying factors based on the materials and the condition of the bridge.

(1) Provisional class number.

(a) Mark span length (S in fig. 110) on col. A of figure 111.

(b) Mark total crown thickness (t + D in fig. 110) on col. B of figure 111.

(c) Draw a straight line through the points marked in steps (a) and (b), and where this line intersects col. C, read the provisional class number.

(2) Profile factor

(a) Divide span length (S in fig. 110) by the rise (R in fig. 110) and mark the result at the bottom of figure 112. If the result is 4 or less, profile factor is 1. Otherwise . . .

(b) Draw a vertical line from the mark made in step (a) and mark the point where it intersects the curved line.

(c) Draw a horizontal line from the mark made in step (b) to the left edge of figure 112 and read the profile factor at this point.

(3) Other factors (See table 42). Select the material, joint, deformation, crack, abutment size, and abutment fault factors from the table. Use only those factors which apply.

(4) Actual class number. Multiply the provisional class number by each of the various factors found above. The result is the bridge classification number.

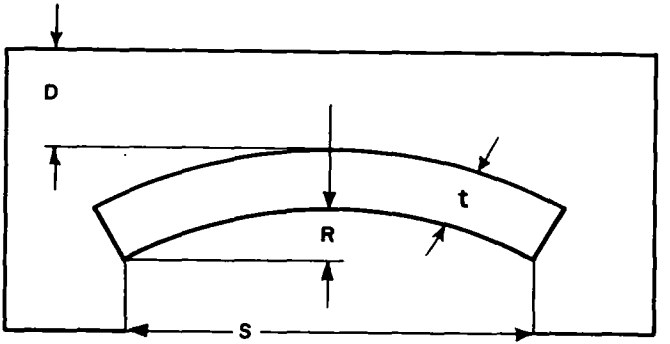


Figure 110. Masonry arch bridge.

EXAMPLE 3. Given: Mosonry orch bridge, span (S), 40 ft; rise (R), 8 ft; orch ring thickness (t), 18 in; depth of fill at crown (D), 12 in; raodway width, 15 ft; material, lime-stone in good condition; joints, martor, some deteriorotion, small voids, close jaints; cracks - lorge langitudinal crack in arch under one parapet wall; abutments - ane opprooch up a narrow embankment.

Find Bridge Closs - Solution: Roadwoy width limits bridge to one lone. Total crown thickness (t = D, see fig. 110) = 18 in. + 12 in. = 2.5 ft. Using figure 111 line up stroight edge ot spon of 40 ft. (col. A) and total crown thickness of 2.5 ft. (cal. B). At the intersection of stroight edge ond Cal. C, read provisianol closs number, 34.

Determine the profile factor. Span/rise rotio = 40/8 = 5. Enter the bottom of figure 127 with the spon-rise ratio ond drow o verticol line. At the intersection of this vertical line ond the curved line an the graph, pivat (going horizontally) to the left edge of the chart. Read the profile factor as 0.86.

Moterial foctor far limestone in gaod candition is 1.0. Joint factor is between 0.80 ond 0.70, soy 0.75. Crack foctor for one crack at the edge of the ring is 0.90. Abutment foctor for one unsotisfoctory obutment is 0.95.

Determine octuol closs number by multiplying provisionol closs number by foctors found obove.

Actuol closs number = 34 x 0.86 x 1.0 x 0.75 x 0.90 x 0.95 = Class 19.

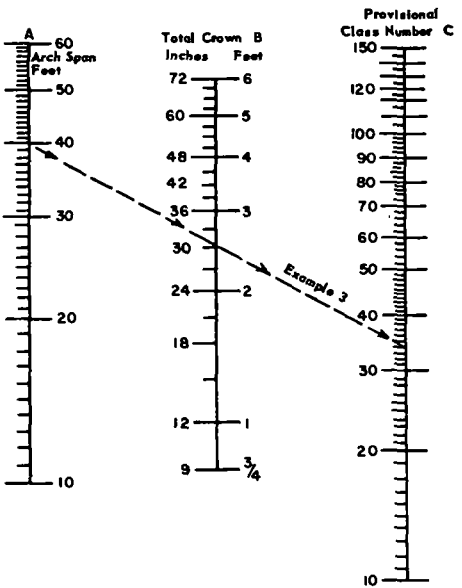


Figure 111. Chart for determining provisional load class of arch bridges.

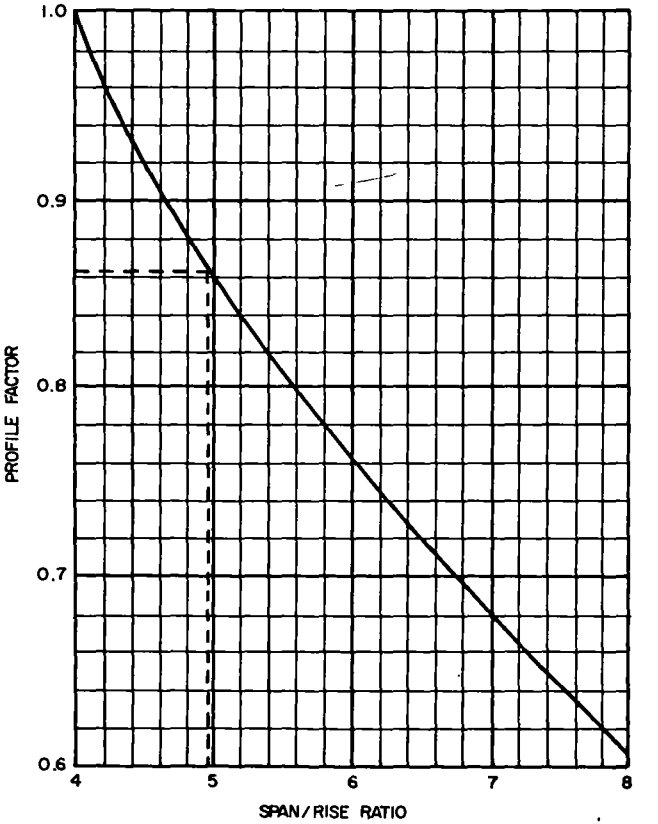


Figure 112. Profile factors for arch bridges.

n. Reinforced Concrete Bridge

(1) Due to wide variations in design criteria, it is not possible to calculate the exact capacity of a reinforced concrete bridge based only on the measureable external dimensions. Therefore, when information is available pertaining to the design loading or civil load rating for the bridge (from a local agency or from intelligence reports), the class will be obtained by correlation if charts are available relating civilian design load to the military class for various span lengths. Such charts are available in TM 5-260 for many United States and foreign civilian design loads, or they may be developed within certain Army areas.

(2) When the necessary information is not available for classification by correlation, the expedient methods shown may be used.

(3) Slab Bridges: Measure the span length from center-to-center of supports in feet, the roadway width (W) in feet, and the depth (D) of the concrete slab, exclusive of any wearing surface or fill, in inches (fig. 114). Enter figure

Table 42. Arch Factors

Material Factor	
1. Granite, whitestone, and built-in-course masonry	−1.5
2. Concrete or blue engineering bricks	−1.2
3. Good limestone masonry and building bricks	−1.0
4. Poor masonry or brickwood (of any kind)	−0.7 −0.5
Joint Factors	
1. Thin joints, 1/10 in or less in width	−1.25
2. Normal joints, with width up to ¼ in.	−1.00
3. Ditto, but with mortar unpointed	−0.90
4. Joints over ¼ in wide, irregular good mortar	−0.80
5. Ditto, but with mortar containing voids deeper than 1/10 of the ring thickness	−0.70
6. Joints ½ in or more wide, poor mortar	−0.50
Deformation Factors	
1. The rise over the affected portion is always positive	Apply span-rise ratio of affected portion to the whole arch.
2. Flat section of profile	Max class: 12
3. A portion of the ring is sagging	Max class: 5, if fill at crown exceeds 18 in.

Crack Factors

1. Small cracks within 2 ft of the edge		−1.0
2. Large cracks within 2 ft of the edge		−1.0
3. Longitudinal cracks in center third of bridge	−0.9	−0.7
one small crack		−1.0
one large crack or several narrow cracks		−0.5
4. Small lateral and diagonal cracks		−1.0
5. Large lateral and diagonal cracks	Mox class: 12, or figure derived by using the other factors.	
6. Cracks between the arch ring and parapet wall due to lateral spread of the fill		−0.9
7. Cracks between the ring and spandrel, due to a dropped ring	Reclassify from the nomograph, on assumption that crown thickness is that of ring alone.	

Abutment Size Factors

1. Both abutments satisfactory	−1.00
2. One unsatisfactory abutment	−0.95
3. Both abutments unsatisfactory	−0.90
4. Both abutments massive, clay fill suspected	−0.70
5. Arch supported on 1 abutment and 1 pier	−0.90
6. Arch supported on 2 piers	−0.80

Abutment Fault Factors

1. Inward movement of 1 abutment	−0.75	−0.50
2. Outward spread of abutments	−1.00	−0.50
3. Vertical settlement of 1 abutment	−0.90	−0.50

113 with the span length, drawing a vertical line until it intersects the curve representing the depth (D) of the slab and estimating where necessary where this point should be. From this intersection draw a horizontal line to read the value of "m." Determine "M" by the formula

$$M = W_L m,$$

in which W_L equals the width of one lane in feet. Enter the graph in figure 104 with this value of "M" and the span length to obtain the class of the bridge.

EXAMPLE 4. Given: Two-lane concrete slab bridge; 20-ft span length, D = 16"; 22-ft roadway width.

To find bridge class: Roadway width limits two-way class to classes 4 to 30. From chart in figure 113, m = 37. The width of one lane is 11 feet, therefore $M = W_L m = 11 (37) = 407$. With this value of "M" and the span length, obtain class 52 wheeled

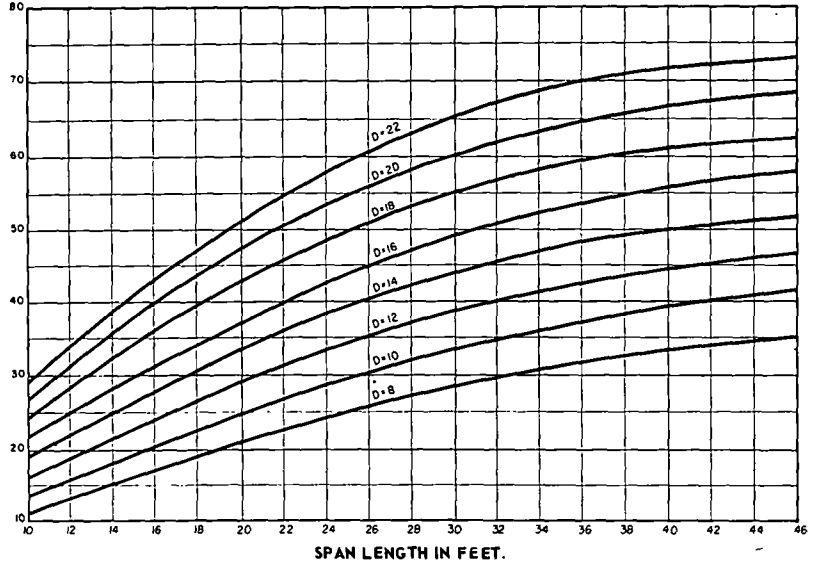


Figure 113. Moment for reinforced concrete slab bridges.

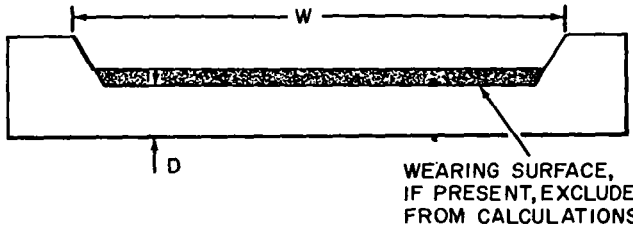


Figure 114. Cross-section of RC slab bridge.

and class 36 tracked from the graph in figure 104.

Two-way Class: Bridge is class 30 as limited by roadway width.

One-way Class: Effective width of roadway is 15'. Therefore, M = 15 (37) = 555. Bridge is class 75 wheeled and class 54 tracked.

T-BEAM BRIDGES: Make the necessary measurements as shown in figure 115 and find L, the span length from center-to-center of supports. All dimensions are in inches except L and W, which are in feet. Calculate "M" by the formula:

$$M = N\,[158 + D\,(1.07T + 0.34L + 0.027S + 0.77b - 24.1)] + 0.08L^2$$

Enter the graph in figure 104 with this value of "M" and the span length to obtain the class of the bridge.

EXAMPLE 5. Given: Two-lane concrete T-Beam bridge; 32-ft span length; 7 T-beams, S = 48", D = 30", b = 12", T = 6"; 24-ft roadway. (See fig. 115).

To find bridge class: Roadway width limits two-way classes 4 to 60. Number of stringers per lane = 3.5.

$$M = 3.5[158 + 30\,(1.07\,\{6\} + 0.34\{32\} + 0.027\{48\} + 0.77\,\{12\} - 24.1)] + 0.08\,(32)^2$$

$$M = 3.5[158 + 30\,(6.42 + 10.88 + 1.30 + 9.24 - 24.1)] + 82$$

$$M = 3.5[158 + 30\,(3.74)] + 82 = 3.5\,(158 + 112.2) + 82 = 1028$$

With this value of "M" and the span length, obtain the class from the graph in figure 104.

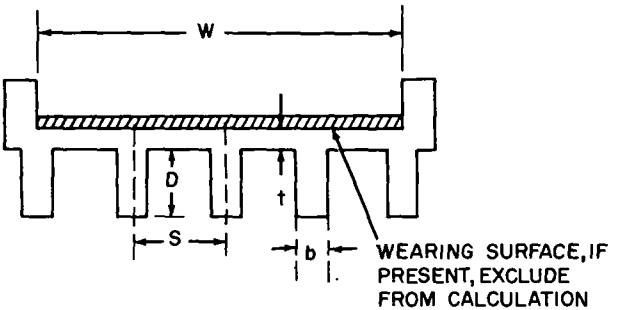


Figure 115. Crass-sectian af RC T-beam bridge.

Two-way class: Bridge is class 60 wheeled as limited by raadway width and class 50 tracked.

One-way class:

$$\text{Effective No. of Str.} = \frac{15}{\text{raadway width in feet}} \times \text{No. af Str.} = \frac{15}{24} \times 7 = 4.375$$

M = 4.375 [158 + 112.2] + 82 = 1264

Bridge is class 95 wheeled and class 63 tracked.

o. Truss Classificatian. For expedient classificatian af truss bridges, assume that the stringers are the critical members. Consider that the c-to-c distance between panel paints (fig. 116) is the span length of the stringers and calculate stringer capacity as far the trestle bridge.

p. Light Suspensian Bridge.

(1) Data. See information in table 43 and figure 102.

(2) Example af main-cable design. Determine tension in main cables far a 200-faat-span suspensian bridge with a suspended weight af 10 tans. Assume a 10-percent sag ratia and a 4-tan line laad.

Suspended weight	20,000 lb.
Line laad	8,000 lb.
Impact	8,000 lb.
Total	36,000 lb.

Table 43. Light-Suspension Bridge Design Data

Item	Data
Panel length	10 to 15 ft.
Camber	Approximately 2 ft.
Stringer design	See paragraphs 51h and j
Floor beams	4" x 4" for foot troops or pack animals. 6" x 6" for ¼-ton truck. 8" x 8" for ¾-ton truck.
Stress in suspenders	Design for dead load of one panel, live load and 100% of live load for impact. See table 103 for cable strength.
Length of suspenders	$h = L + \left(\frac{n}{N}\right)^2 (C + d)$ See figure 137 for meaning of symbols.
Sag ratio	5% for foot bridges to 10% for animal and light vehicle bridges.
Main-cable design	See table below
Towers	12" x 12" posts and caps will take loads, including a 2½-ton truck. 6" to 8" timber side, back, and forebraces. ½" wire-rope side and back guys. 1 to 1 slope for side guys; 2½ horizontal to 1 vertical slope for back guys.
Anchorage	Deadman or other anchorage must hold maximum tension of main cable.
Factor of safety	Wire rope = 2 Cordage = 3.5

Sag ratio %	Max total tension in main cables, in parts of total suspended weight of bridge and load.	Length of cable between towers, in parts of span length
7	1.94	1.012
8	1.57	1.018
9	1.46	1.022
10	1 35	1.026
11	1.23	1.033
12½	1 12	1.041
16 2/3	0.90	1.070

Maximum total tension in main cables for a 10-percent sag ratio = 36,000 x 1.35 = 48,600 pounds. If two main cables are used, each must have a tensile strength of 24,300 pounds.

S2. **CONSTRUCTION AND PROCUREMENT DATA** (Standard Fixed and Floating Bridges)

a. **Steel Panel Fixed Bridge, Bailey Type, M2.**

(1) See figure 94 for data.

(2) Panel bridge parts may be transported on twenty-two, 5-ton dump trucks. The loading plan is based on the experience that the double-single truss assembly provides for most bridging problems which require the panel bridge, Bailey type, M2. The loads have been arranged on the basis of the above vehicles capable of carrying all parts issued for a 130-foot DD bridge, including spares. The engineer panel bridge company is the TOE unit designated to carry one bridge set and provide technical personnel and equipment to transport and supervise erection of panel bridging.

(3) The organization of assembly details is given in table 44.

(4) Figures 117 through 122 depict roller and equipment layout.

(5) For parts required, see TM 5-277.

(6) Other data is shown in tables 45 through 50.

(7) For the dual classification Bailey type, M2 bridges see table 36.

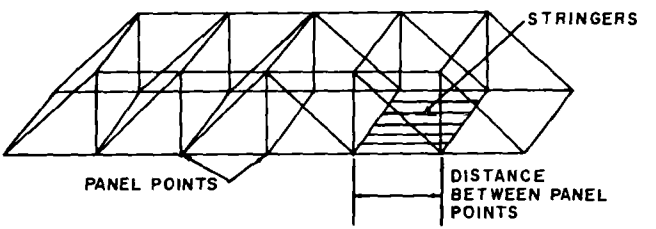


Figure 116. Truss bridge.

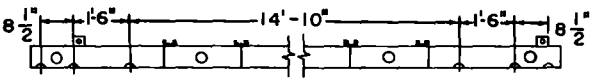


Figure 117. Transom used as template

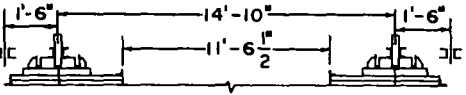


Figure 118. Plain roller, SS, DS, bridges.

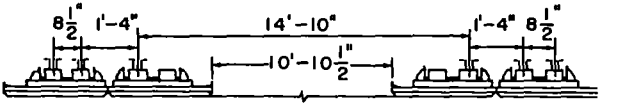


Figure 119. Plain roller, TS, DD, TD, DT, TT, bridges.

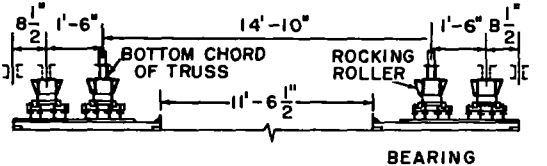


Figure 120. Layout of rocking-roller template.

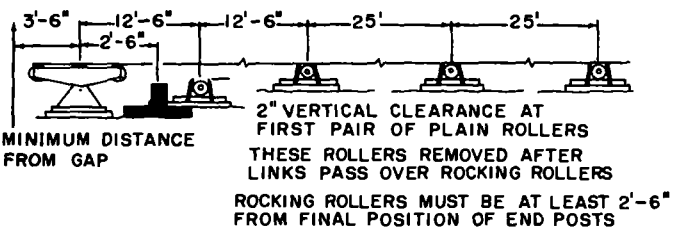


Figure 121. Vertical clearance necessary for removing first pair of near-shore plain rollers after links pass rocking rollers.

Table 44. Organization of Assembly Details

	NO. OF NCOs AND EM								
	Type of bridge								
	Single-single	Double-single	Triple-single	Double-double	Triple-double	Double-triple	Triple-triple	Double-triple	Triple-triple
	Construction by manpower only							Using 1 crane*	
CRANE	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0–3	0–3
Truck driver	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(1)	(1)
Crane operator	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(1)	(1)
Hook man	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(1)	(1)
PANEL	1–14	1–14	2–28	2–32	3–50	3–50	3–68	3–30	3–30
Carrying	(12)	(12)	(24)	(28)	(44)	(44)	(60)	(24)	(24)
Pin	(2)	(2)	(4)	(4)	(6)	(6)	(8)	(6)	(6)
TRANSOM	1–9	1–10	1–10	1–10	1–10	2–28	2–28	2–20	2–20
Carrying	(8)	(8)	(8)	(8)	(8)	(24)	(24)	(16)	(16)
Clamp	(1)	(2)	(2)	(2)	(2)	(4)	(4)	(4)	(4)
BRACING	1–4	1–6	1–8	1–12	1–20	1–32	1–40	1–32	1–38
Sway brace	(2)	(2)	(2)	(2)	(2)	(6)	(6)	(6)	(6)
Raker	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Bracing frame	. . .	(2)	(2)	(4)	(4)	(8)	(8)	(10)	(8)
Chord bolt	. . .	. . .	. . .	(4)	(8)	(10)	(14)	(10)	(14)
Tie plate	. . .	. . .	(2)	. . .	(4)	. . .	(4)	. . .	(4)
Overhead supp't	. . .	. . .	. . .	. . .	. . .	(6)	(6)	(4)	(4)
DECKING	1–12	1–12	1–12	1–12	1–12	1–12	1–12	1–12	1–12
Stringer	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)
Chess and riband	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Total	4–39	4–42	5–58	5–66	6–92	7–122	7–148	7–97	7–103

*Normally, a crane is not used for single- or double-story assembly.

Table 45. Bailey Bridge Launching Construction

Bridge Type	Span ft.	No. of bays in nose SS	DS	DD	Distance of links from tip of nose ft.	Required distance behind rocking rollers, ft.
SS	30	2			—	35
	40	3			—	43
	50	3			—	47
	60	4			10	55
	70	5			20	63
	80	5			20	67
	90	6			30	75
	*100	*6			30	76
DS	50	3			—	45
	60	4			10	52
	70	4			10	57
	80	5			20	64
	90	6			20	71
	100	6			20	76
	100	7			30	83
	120	8			40	90
	130	8			10 & 40	95
	*140	*8			10 & 40	96
TS	80	5			2[illegible]	63
	90	6			20	70
	100	6			20	74
	110	7			30	81
	120	7			30	86
	130	8			40	93
	140	9			10 & 40	100
	*150	*9			20 & 40	101
	*160	*9			20 & 40	106
DD	100	6			20	74
	110	7			20	81
	120	7			30	86
	130	8			30	93
	140	7	2		40	100

Bridge Type	Span ft.	No. of bays in nose SS	DS	DD	Distance of links from tip of nose ft.	Required distance behind rocking rollers, ft.
DD (*)	150	6	*3		40	106
	*160	*6	*3		40	106
	*170	*7	*3		10 & 40	113
	*180	*7	*3		20 & 40	117
TD	110	6			20	77
	120	7			20	84
	130	6	2		30	90
	140	5	3		30	96
	150	5	4		40	103
	*160	*5	*4		40	106
	*170	*6	*4		10 & 40	112
	*180	*7	*4		10 & 40	125
	*190	*7	*4		20 & 40	126
DT	130	5	3		30	91
	140	5	3		30	96
	150	5	4		30	102
	160	5	5		40	109
	*170	*5	*5		40	112
	*180	*5	*5		40	116
	*190	*6	*5		10 & 40	131
	*200	*7	*5		20 & 40	132
	*210	*7	*5		30 & 40	135
TTT	*160	*5	*5		40	94†
	*170	*5	*6		40	96‡
	*180	*6	*2	*2	40	102†
	*190	*6	*6	*2	10 & 40	112†
	*200	*6	*6	*4	20 & 40	115†
	*210	*7	*5	*6	30 & 40	117†

*Spans launched incomplete. See following table
†Estimated.

LAUNCHING TT BRIDGES 1. Launch until near-bank rocking rollers are under last TT bay of initial construction 2. Add up to six bays TT bays to tail of initial construction This completes all but 210-foot span. 3. Continue launching until near-bank rocking rollers are under last TT bay added in step 2. 4 Add remainder of TT bays to complete bridge (210-foot span only). 5 Add five bays DS nose-type construction to tail of bridge. 6. Launch forward until first three DT bridge bays are beyond far-bank rollers. 7. Complete first three bridge bays by converting to TT and adding transoms 8 Pull bridge back to final position, remove DS tail, add decking where needed, and jack down.

Table 46. Bailey Bridge Spans
Launched Incomplete

Type	Span, ft.	No. of bays, docking & stringers	Omitted of top story
SS	100	4	
DS	140	6	
TS	150	6	
	160	10	
DD	160	7	
	170	7	
	180	12	2
TD	160	3	
	170	10	
	180	All	
	190	All	3 1/3
DT	170	3	
	180	8	
	190	All	
	200	All	3
	210	All	5
		No. of bridge bays in initial construction *	
TT	160	3	14
	170	6	14
	180	6	14
	190	All	15
	200	All	14
	210	All	13

* First three bridge bays are constructed DT with only one transom per bay. Last bridge bay is constructed DT because of staggered construction necessary when adding subsequent bays.

Table 47. Number of Jocks Needed ot Each End of Boiley Bridge

Type	Span, ft.	No. of jacks needed at each end of
SS	30-100	2
DS	50-140	4
TS	80-140	4
	150-160	6
DD	100-120	4
	130-180	6
TD	110-140	6
	150-190	8
DT	130	6
	140-180	8
	190-210	10
TT	160-170	10
	180-210	12

Table 48. Number of Rocking Rollers Needed for Boiley Bridge

Type	Span, ft.	Near bank	Far bank
SS	30-100	2	*
	50-80	2	*
DS	90-100	2	2
	110-140	4	2
TS	80-160	4	2
DD	100-130	4	2
	140-180	4	4
TD	110-120	4	2
	130-190	4	4
DT	130-210	4	4
TT	160-210	4	4

* Use two plain rollers

Table 49. Weight per Bay of Bailey Bridge

Construction	Weights per bay, tons
BRIDGE	
SS	2.76
DS	3.41
TS	4.01
DD	4.66
TD	5.88
DT	6.46
TT	8.29
LAUNCHING NOSE	
SS	1.00
DS	1.64
DD	2.90
DECKING	
Stringers only	0.79
Chess and stool ribands	0.66
FOOTWALKS	0.17
OVERHEAD BRACING	
Supports, transoms, sway bracing, and chord bolts	0.54
WEAR TREAD AND TRUSS GUARDS	0.35
NOTE: Footwalks, wear treads, and truss guards not included. Overhead bracing included on DT and TT.	

Table 50. Critical Dimensions of Bailey Bridge

Road width between steel ribonds	12' 6"
Road width between timber truss guards	13' 9"
Lateral distance between centerlines of trusses:	
Inner trusses	14' 10"
Middle trusses	17' 10"
Outer trusses	19' 3"
Lateral distance between centerlines of base plates:	
S truss bridge	14' 10"
D truss bridge	16' 4"
T truss bridge	17' 3½"
Lateral distance between outside edges of base plates:	
S truss bridge	19' 5"
D truss bridge	20' 11"
T truss bridge	21' 10½"
Lateral distance between measuring lugs of rocking roller templates	11' 6½"
Lateral distance between measuring lugs of plain roller templates:	
SS, DS bridges	11' 6½"
TS, DD, TD, DT, TT bridges	10' 10½"
Longitudinal spacing between plain rollers	25'
Height from base of base plate to top of chess	28 5/16"
Height from base of rocking roller template to top of rocking roller	16 5/16"
Height from base of plain roller templated to top of plain roller	8 15/16"
Height from base of ramp pedestal to top of ramp chess	17 ¼"
Height from bottom of half round lug under sloping end of ramp to top of ramp chess	5 7/8"
Height from top of chess to overhead bracing:	
Normal	14' 7"
Expedient	12' 3"
Height from base of bearing to bottom of panel	5 17/32"
Height from bottom of panel to top of chess	20 11/16"
Height from bottom of half round lug of end post to top of chess	22 13/32"
Height from base of rocking roller bearing to top of rocking roller	13 5/16"

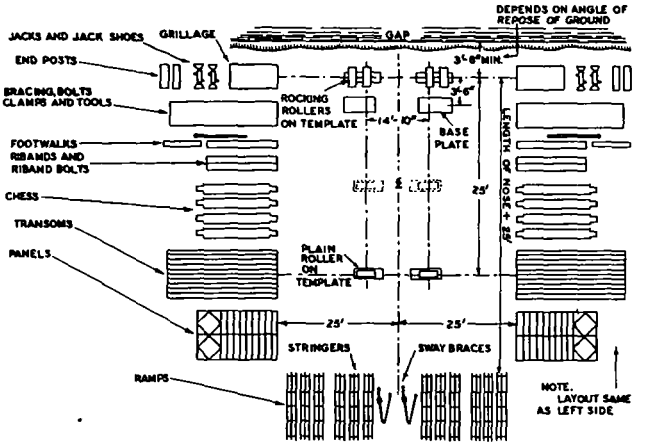


Figure 122. Layout of equipment at bridge site.

b. Class 60 Fixed Bridge.

(1) Single spans:

20 - 30-foot	10 - 60-foot
13 - 45-foot	8 - 75-foot

(2) Multiple spans:

1 - 165-foot with 6 trestles	1 - 420-foot with 6 trestles
1 - 225-foot with 6 trestles	1 - 525-foot with 6 trestles

(3) Transportation of the components of this class 60 fixed bridge set is done in the 5-ton, 6 x 6 military bridging truck. Ropes, hoists, and accessories are carried on 2½-ton cargo trucks.

c. Aluminum Floating Footbridge. For construction and transportation data, see table 51.

d. Bridge, Floating, Aluminum Deck-Balk Superstructure (M4T6).

(1) The plan is illustrated in figure 123.

(2) Construction and transportation data is seen in table 52.

Table 51. Construction and Transportation Data of Aluminum Floating Footbridge

Bridge set	Basis of issue	Suggested working party		
		Detail	NCO	EM
Normal Assembly: 472 ft 6 in.	One set to each engineer float bridge company	Near-shore anchor cable		6
Light vehicle bridge: 100 ft.	Vehicles required for transportation of bridge set:	Far-shore anchor cable	1	6
Expedient rafts: 3	Two 2½-ton 6 x 6 cargo trucks with 2½-ton pole-type trailers or 3 2½-ton cargo trucks.	Bridle line		2
Major items:		Guy line		5
Pontan 42		Shore assembly	1	5
Treadways 42		Assembly carrying		6
		River assembly		5
		Handrail		3
		Total	2	38
		Plus 2 EM per 100 ft of bridge.		

Table 52. Construction and Transportation Data of M4T6

Bridge set	Basis of issue	Suggested working party			
		Detail	No. of crews	NCO	EM per crew
Normal floating bridge, 141 ft. 8 in.	Engineer float bridge company (5 bridge sets of 141' 8" each for a float bridge company at full strength, and 3 sets for a company at reduced strength)	Float inflation	1	1	8
One 4-float and one 5-float reinforced raft,		Saddle assembly	2	1	10
		Assembled float delivery	1	1	2
2 floating bridges, 75 ft., one without reinforcing bolt on end float,		Bolt-carrying from shore	1	2	40
		Bolt-laying	1	1	12
3 38 ft. 4 in. span fixed bridges.		Anchorage	1	2	12
		Near-shore abutment	1	1	8
		For-shore abutment	1	1	8
		Total	9	10	100

e. **Floating Bridge, M4.**

(1) For the plan, see figure 88.

(2) Construction and transportation data is in table 53.

Table 53. Construction and Transportation Data of M4

Bridge set	Basis of issue	Suggested working party		
	Class IV	Detail	NCO	EM
Floating bridge: 608 ft 4 in.	Vehicles required for transportation of bridge set:	Near-shore abutment	1	8
Fixed bridges:		Ponton outfitting (2 crews)	4	36
2-23 ft	¾-ton cargo truck	Ponton delivery (2 crews)	2	10
2-30 ft	2½-ton cargo truck	Anchorage	2	12
2-38 ft	2½-ton truck, bolster	Bolk carrying	2	88
2-45 ft	2½-ton bolster trailer	Bolk laying	1	8
Rafts:	2½-ton pole type trailer	For-shore abutment	1	16
4-4-ponton	4-ton dump truck	Pin checking	1	3
4-6-ponton		Total	14	181
4-7-pontan				

f. **Class 60 Bridge.** Construction and transportation data is in table 54.

g. **Light Tactical Bridge.** The assembly of the normal light tactical bridge is generally similar to that of the normal 5-ponton raft. The organization for assembly is given in table 55. With a trained crew, during daylight hours, and in still water, this bridge can be erected at the rate of 3 1/3 feet per minute.

h. **Armored Vehicle Launched Bridge.**

(1) The method used to assemble the bridge depends on the state of disassembly of the bridge for transporting, i.e., it would be completely disassembled for transporting on bridge trucks, or it would be separated lengthwise for rail or low-bed trailer shipment.

Table 54. Construction and Transportation Data of Class 60

Bridge set	Basis of issue	Suggested working party		
		Detail	NCO	EM
Floating bridge: 607 ft.	Class IV	Supervisory	2	
		Crane crew	1	1
Fixed bridges: 20-30 ft 13-45 ft 10-60 ft 8-75 ft 1 multispon from 165 to 525 ft.	Vehicles required for transportation of bridge set:	Saddle assembly - 2 crews.	2	20
		Float inflation.		9
		Deck panel	1	6
		Float handling.		8
	5-ton 6 x 6 military bridging truck carries one complete bay, 2½-ton cargo truck carries accessaries	Single bay, connecting	1	6
		Boat crew.		4
		Bridge assembly.	1	8
		Anchorage	1	10
		Trestle.	1	8
Rafts: 2-4, 5, or 6 float.		Total	10	80

Table 55. Organization for Assembly of Light Tactical Bridge by Successive Pontons

Details	NCO	EM	Summary of tasks
Ponton	1	10	Unload, launch, and join half pontons.
Deck	1	10	Unload and place deck panels, curbs and filler panels on pontons.
Ponton delivery		2	Deliver complete bays to bridge-connecting site.
Bridge connecting	1	4	Connect assembled bays to the bridge.
Near-shore abutment	1	8	Construct near-shore abutment; connect articulator and ramps; and maintain bridge alinement.
For-shore abutment.	1	8	Construct far shore abutment; install end section articulator and ramps.
Anchorage	2	12	Install anchor cable, bridle lines, and shore guys (see TM 5-210)

(2) For details of assembly, launching and retrieving, see TM 5-216. A two-man crew with authorized equipment is required.

i. **Amphibious Mobile Assault Floating Bridge.**

(1) A four-man crew, consisting of a driver, pilot, and two crew men, is required to operate the vehicle on land, in the water, and during bridge construction.

(2) The ABV-60 enters the water ready for incorporation onto a bridge or raft as a 26'3" floating section. All movements of the decking during construction are hydraulically controlled. As successive units enter the water they are joined until the required length of bridge or raft has been built, then ramps are added to each end.

(3) The ARV-60 is transported by the ABV-60. The carrier unit positions the ramp for connection to the bridge or raft and is disengaged when the connection has been made. All movement of the ramp during construction and operation is done by the hydraulic system of the carrier and bridge vehicle to which it is connected.

(4) For rafting, the construction procedure for 2-, 3-, 4-, and 5-unit rafts is similar to that used for the bridge. Time required varies from 15 minutes (2-unit) to 25 minutes (5-unit). In each case, about 10 minutes are required for connection of the ramps.

53. STANDARD RAFT

a. **Light Tactical Raft.**

(1) The deck of the light tactical raft consists of aluminum decking and filler panels. The unit of issue of this raft provides components of one 4-pontoon normal raft. As a reinforced raft, the loading space from the outside edge of the pontons is approximately 29½ feet. This same set is used in assembling rafts of various classes.

(2) The construction time for assembly of the light tactical raft is given in table 56.

(3) The light tactical raft components are normally transported on two 2½-ton cargo trucks and one 2½-ton pole-type trailer. With each raft set there are four chain slings, four binders, and one cradle; the chain slings and binder

Table 56. Construction Time for Light Tocticol Raft

Type of ossembly	NCO	EM	Time required, minutes
4-ponton, 3-bay. . . .	3	27	15
5-ponton, 5-bay. . . .	3	27	20
6-ponton, 4-boy. . . .	3	27	30

to secure the roft sets on vehicles, and the cradle to nest the holf pontons on the trailer. The eight deck panels, eight filler panels, and eight long curbs of the superstructure are transported on the 2½-ton truck used to haul the troiler. Another 2½-ton truck tronsports the articulating assemblies, ramps, ponels, articulator and ramp curbs, orticulotor ond ramp fillers, anchors, ond holdfasts.

(4) The porty operoting the roft is normally under the supervision of an NCO and comprises o raft crew, a neor-shore crew, ond a for-shore crew. Table 57 outlines their duties.

Table 57. Duties of Porty Operoting Light Toctical Roft

Crew	No. of men	Duties
Roft	8	4 men operate outboard motors; 4 men place ond remove chocks from wheels of vehicles.
Neor shore	1	1 man guides vehicles onto roft ond instructs drivers in proper operotion of vehicles while being looded ond unlooded.
Far shore	1	1 man guides vehicle off raft.
Guy line	4	Hondle guy lines.

b. M4 Raft.

(1) The bosic 4-ponton roft con be converted to o reinforced roft with greater load copacity by adding reinforcing pontons. The other recommended types of rafts ossembled from M4 bridge equipment are the 6-ponton ond 7-ponton, both reinforced (fig. 90). These closses of rofts ore given in toble 34.

(2) The amount of time and the number of trained men required for the assembly of M4 rafts are given in table 58.

Table 58. Time and Labor to Assemble M4 Raft

Type of assembly [1]	Time, hr.[2]
4-pontoon raft, 15-ft spacing	2
4-pontoon raft, short deck	2
Normal rafts, reinforced	
5-pontoon	2½
6-pontoon	3
7-pontoon	3½
5-pontoon raft, short deck	2½

[1] One platoon is required for each type of assembly.

[2] For night assembly, increase time 50 percent.

Assembly time does not include time for preparing landing site, landing stage, or approach roads. The larger rafts (5-, 6-, or 7-pontoon) are assembled by adding one, or more, pontoons to this 4-pontoon raft. The reinforcing pontoon(s) is centered between the center pontoons and fastened to them by four reinforcing pontoon spacers. From five to seven bolster-body trucks, depending upon the number of added pontoons, are required for transportation.

(3) These rafts are propelled by bridge erection boats or outboard motors, as auxiliary power (see table 34 for capacities).

c. **Class 60 Rafts.** See plans of this class 60 raft in figure 91. Other data may be reviewed in table 34.

d. M4T6 Raft.

(1) An example of the M4T6 raft is illustrated in figure 123.

(2) More detailed data of this M4T6 raft is presented in table 34.

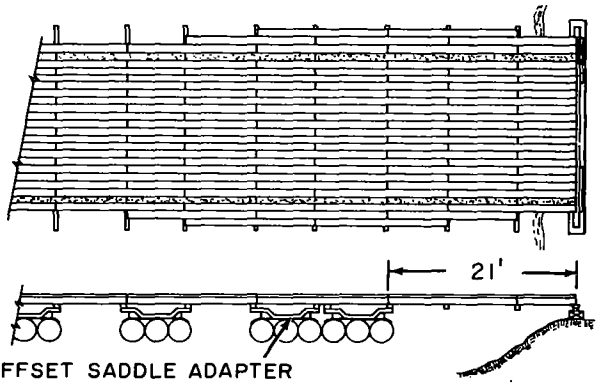


Figure 123. Bridge, floating, aluminum deck-balk superstructure (M4T6).

For information about connection of the M4T6 bridge to the M4 and closs 60 floating bridges, see TM 5-210, with chonge 1.

CHAPTER 6

CONSTRUCTION

Section I. Concrete

54. IMPORTANT FACTORS

The important considerations in mixing good concrete are:

a. **Plastic Mixtures.** For plastic mixtures, using sound, clean sand, coarse aggregate, and adequate placement procedures the strength of concrete under given job conditions depends upon the net quantity of mixing water used per sack of cement. This knowledge has made possible the effective and practical means of concrete strength.

b. **Sand and Aggregate.** Assuming that proper cement is available, the first item of importance for a specific concrete job is the availability of suitable sand and coarse aggregate. Water may be located in most regions, although some water should not be used, pointed out in paragraph 57 below.

c. **Strength.** Factors affecting the strength of one mix relative to another mix of this same water content are strength, gradation, cleanliness, and shape of the aggregate particles. With suitable materials available, proper portions of each can be determined by a mix design procedure given in paragraph 58.

d. **Mix.** The amount of sand and coarse aggregate required for each batch should be carefully measured by weight or volume.

e. **Mixing Time.** The recommended mixing time for a 1-cubic-yard mixer is 1 minute, with an added 15 seconds for each additional ½ cubic yard or fraction thereof.

55. CONCRETE MATERIALS

a. Formulas.

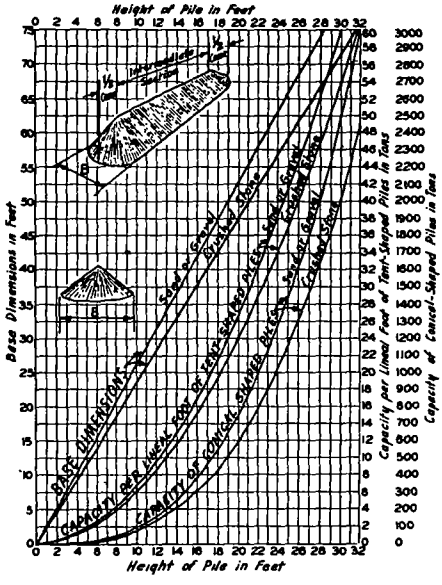
(1) A good formula by which to estimate the weight and volume of aggregate is: Volume = 0.2618 x height x diameter (squared).

(2) The graph in figure 124 gives the method of estimating both volume and weight of aggregate in a pile or storage.

b. **Storage Capacity.** An explanation for using above the three pairs of curves in figure 124 considers the following:

(1) The capacity of the conical-shaped piles is determined from the two curves on the far right and the vertical column on the outside right. You could determine, for example, that a stockpile of crushed stone 30 feet high has a capacity of 2,010 tons.

(2) In determining the capacities per lineal foot of tent-shaped piles, note that the two ends of these piles are equivalent to one conical pile, and their capacity can be determined in the manner described in a above. The


Height of Pile in Feet
Base Dimensions in Feet
Capacity per Lineal Foot of Tent-Shaped Piles in Tons
Capacity of Conical-Shaped Piles in Tons
Coal or Gravel
Crushed Stone
Sand or Gravel
Crushed Stone
BASE DIMENSIONS
CAPACITY OF TENT-SHAPED PILES PER LINEAL FOOT
CAPACITY OF CONICAL-SHAPED PILES
Height of Pile in Feet

Curves based on:

Unit weight of aggregate of 100 pounds per cubic foot. Angle of repose of sand and gravel of 37°. Angle of repose of crushed stone of 40°.

Figure 124. Storage capacity curves.

capacity of the intermediate section for various heights is determined by using either of the two curves in the middle of the chart and the vertical column on the inside right. For example, a stockpile of gravel 19 feet high has a capacity of 24 tons per lineal foot. The capacity of the 2 end sections is 630 tons: therefore the total capacity of a stockpile with a 50-foot-long intermediate section would be 24 x 50 + 630, or 1,830 tons.

(3) The vertical column of figures on the left gives the diameter or width (B) of conical or tent-shaped stockpiles of various heights. For example, a 17-foot-high conical pile of sand has a base diameter of 45 feet. A 17-foot-high tent-shaped pile of crushed stone has a base width of only 41 feet.

c. Water. Water for mixing concrete should be free of foreign matter, such as silt, decayed matter, alkali, sulphates, or salt.

56. DESIGN OF CONCRETE MIXES

a. Water-Cement Ratio.

(1) The amount of water in mixing concrete is of major importance. It is expressed in terms of gallons per sack of cement, or it may be in terms of weight of water per sack of cement to the weight of one sack of cement. Table 59 gives the quantities of water for concrete of given strengths.

(2) Where strength and economy are important, tests for strength should be made with materials under job conditions. These tests should include at least three different water contents. The 15 percent safety factor used with table 59 should be used here.

(3) The gallons of water per sack of cement to make durable concrete for various conditions is shown in table 60.

(4) How much the strength of concrete increases with time is shown in figure 125. For example, at the end of 14 days the strength gain is slightly less than 90%.

Table 59. Relations Between Mixing Water and Compressive Strength of Concrete*

Water per sack of cement, gal.	Probable average strength, psi	
	7-day strength	28-day strength
4	4,400	6,000
5	3,500	5,000
6	2,800	4,000
7	2,200	3,300
8	1,800	2,800

* A safety factor of 15 percent should be allowed when selecting the water content required. If 2,800-psi concrete at 28 days is required, a water content corresponding to a strength of 3,200 psi should be selected.

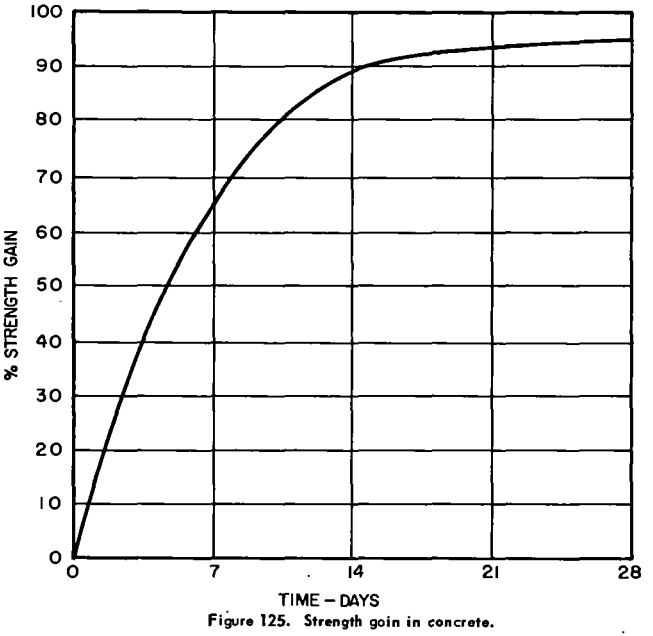


Figure 125. Strength goin in concrete.

b. Consistency.

(1) Immediotely ofter being mixed, cancrete shauld be plostic.

(2) Cansistency is meosured by the slump test. The mix is placed in a cone-shaped form (fig. 126) in 3 layers and radded. Each of the 3 loyers af concrete is rodded with 25 strokes of the temping rad. Each stroke shauld penetrate into the underlying layer, with the bottom layer being radded throughout its entire depth. The form is then removed and the concrete slumps ta a position of equilibrium. It is measured, and the greater the slump, the more fluid the mix. If mare slump is needed for the placing crew to place this mix, the amount of aggregate shauld be changed rather than by adding more water.

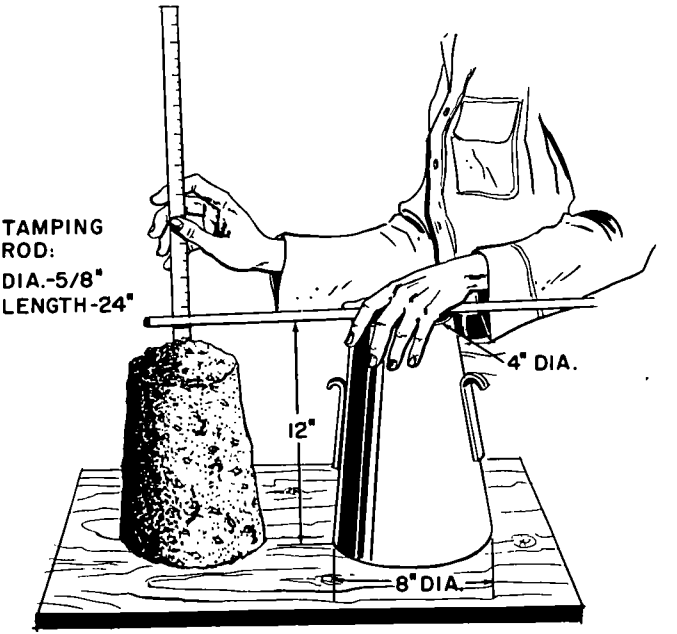


Figure 126. Measurement of slump.

(3) Workability also depends upon where the mix is placed. For example, concrete containing large aggregate particles would be workable in a mass such as a dam, it would not be workable in a relatively thin wall with reinforcing bars.

c. **Trial Method of Mix Design.**

(1) If concrete is mixed properly, every particle of aggregate is surrounded by a cement-water paste and almost all spaces between particles are completely filled with paste.

(2) When economy is an important factor, use as much aggregate as possible

Table 60. Water-Cement Ratios for Various Types of Construction and Exposure Conditions

Type or Location of Structure	Severe or moderate climate, wide range of temperature, rain, and long freezing spells, or frequent freezing and thawing, gal per sack			Mild climate, rain or semi-arid, rarely snow or frost, gal per sack		
	Sections 0 in to 8 in thick	Sections 3 in to 24 in thick	Sections over 24 in thick	Sections 0 in to 8 in thick	Sections 3 in to 24 in thick	Sections over 24 in thick
A. At waterline in hydraulic or waterfront structures or portions of such structures where complete saturation or intermittent saturation is possible, but not where the structure is continuously submerged in water	5	5½	6	5	5½	6
B. Portions of hydraulic or waterfront structures some distance from waterline, but subject to frequent wetting by water	5½	6	6	5½	6½	7
C. Ordinary exposed structures, building, and portions of bridges not coming under above groups	6	6½	7	6	7	7½
D. Complete continuous submergence in water	6	6½	7	6	6½	7
E. Concrete deposited through water	(*)	5½	5½	(*)	5½	5½
F. Pavement slabs directly on ground:						
Wearing slabs	5½	5½	5½	6	6	6
Base slabs	6½	6½	6½	7	7	7
G. Special case: For concrete not exposed to the weather, such as interiors of buildings and portions of structures entirely below ground, no exposure hazard is involved and the water-cement ratio should be selected on the basis of the strength and workability requirements.						

becouse it is cheaper than cement. To get the right proportions of aggregate ond cement, use the trial-mix method.

(3) Mix design by weight.

(a) A mix design may be determined by weight. Compressive strength with various amounts of water is given in the toble 59. The amount of water for moximum durability under different exposures is determined in table 60. For o watertight structure, the moximum number of gallons per sack should be 6. After computing the above omounts of woter per sack for strength, durability, and watertightness, select the smallest figure (in gallons per sack) as the one for the mix, including the free water in the aggregate os well as the woter odded. Next, select the slump best suited for the type of construction from table 61.

(b) Using the selected water-cement rotio and slump, determine the proportions for o trial batch fram tables 60 ond 62. The batch should be at least one-holf the capacity of power mixer. Conduct o slump test. If too great, correct os follows:

1. Increase of 3 percent in aggregote will decrease slump obout 1 inch.
2. Increase of 3 percent in water will increase slump about 1 inch.
3. If the mix is plastic, o chonge in the omount of cement does not appreciably affect the slump.

(4) Mix design by valume. (See toble 62).

(a) This is not as accurate os proportioning by weight. Triol mix quontities ore seen in toble 62 in terms of surface dry compacted weight. Water in sand may increose volume up to 30 percent.

(b) To determine mix proportions, select the quantities by dota in table 62. A trial mix is made and o slump test is token. If the slump test does

Toble 61. Recommended Slumps for Various Types of Construction*

Type of constructian	Slump, in.	
	Maximum	Minimum
Reinforced foundotion walls ond footings	4	1
Plain footings, caissons, ond substructure walls	4	1
Slabs, beoms, reinforced wall	5	2
Building columns	5	2
Pavements	3	2
Heavy moss construction	3	1

* With high-frequency vibrators, reduce the toble volues by one-third.

Table 62. Trial Propartians and Yield Per Sack of Cement*

Water-cement ratio, US gal per sack	Proportions by surface dry weight				Surface dry weight of aggregate per sack of cement, lb		Proportions by volume, cu ft			Yield, cu ft concrete per sack cement
	Slump, in.	Cement	Fine aggregate	Coarse aggregate	Fine	Coarse	Cement	Fine aggregate (dry comp)	Coarse aggregate (dry comp)	
5	½ to 1	1	1.9	3.3	175	310	1	1.6	3.0	4.09
	3 to 4	1	1.7	3.1	160	290	1	1.5	2.8	3.85
	5 to 7	1	1.5	2.8	145	262	1	1.3	2.5	3.01
5½	½ to 1	1	2.1	3.6	200	340	1	1.8	3.2	4.49
	3 to 4	1	2.0	3.3	188	310	1	1.7	3.0	4.22
	5 to 7	1	1.8	3.1	168	290	1	1.5	2.8	4.00
6	½ to 1	1	2.4	3.9	226	366	1	2.1	3.5	4.87
	3 to 4	1	2.2	3.7	206	348	1	1.9	3.3	4.64
	5 to 7	1	2.1	3.4	200	320	1	1.8	3.0	4.43
6½	½ to 1	1	2.7	4.2	254	390	1	2.3	3.8	5.23
	3 to 4	1	2.5	3.9	235	366	1	2.1	3.5	4.99
	5 to 7	1	2.3	3.6	218	340	1	2.0	3.2	4.73
7	½ to 1	1	3.0	4.6	282	433	1	2.6	4.1	5.76
	3 to 4	1	2.8	4.2	262	395	1	2.4	3.8	5.40
	5 to 7	1	2.6	3.9	246	366	1	2.2	3.5	5.12
8	½ to 1	1	3.3	4.7	310	440	1	2.8	4.2	6.10
	3 to 4	1	3.1	4.4	290	415	1	2.6	4.0	5.82
	5 to 7	1	2.9	4.0	272	386	1	2.5	3.7	5.53

*The maximum size of coarse aggregate is 1½ inches.

not show desirable results, the quantities are adjusted, using the three rules for adjusting the mix as given in (3)(b) above.

(5) Hand mixing. If hand mixing is used, the trial batch should be made on the basis of one or less sacks of cement instead of two.

d. Yield.

(1) With no air-entraining agent, assume that the ingredients in concrete form a voidless mass. This is very nearly correct for plastic mixes.

(2) An acceptable field expedient for determining yield is by the 2/3 rule. This rule is used as follows:

(a) Determine the mix and water-cement ratio of 1, 2, 3, that is, 1 sack of cement to 2 cubic feet of sand to 3 cubic feet of gravel. To this, add .87 cubic foot (6.5 gal) of water. The total then is 1 + 2 + 3 + .87 = 6.87.

(b) The sum of this volume is then multiplied by 2/3:

2/3 x 6.87 = 4.58 cubic feet

Therefore, the yield per sack of cement is 4.58 cubic feet.

(c) This 2/3 rule can be further exploited to determine the quantities of all material required for a specific total yield. For example, assume that

916 cubic feet of concrete are required. Using the same ratio as in 2(a) above, you have:

1. $\frac{916 \text{ (total yield required)}}{4.85 \text{ (yield per sack of cement)}}$ = 200 sacks of cement required.
2. 2 cubic feet of sand are used per sack of cement (2 x 200) = 400 cubic feet of sand required.
3. 3 cubic feet of gravel are used per sack of cement (3 x 200) = 600 cubic feet of gravel required.
4. .87 cubic feet of water per sack of cement (.87 x 200) = 174 cubic feet of water required, or 1305 gallons (7.5 gals. per cu. ft.).

(3) Except for lightweight aggregate, a value of 2.65 should be used if the material is not a type listed in table 63.

Table 63. Bulk Specific Gravity of Rock

Rock type	Specific gravity
Traprock	2.90
Quartzite	2.67
Granite	2.62
Limestone	2.49

57. METHODS OF MIXING AND HANDLING CONCRETE

a. Hand-Mixing Concrete. Whether done by weight or by volume, the cement, water, and aggregate must be measured before mixing begins. On the big jobs there are automatic measuring devices. (See TM 5-742 for details.)

(1) Hand mixing must be carefully and thoroughly done. It is efficient only for a few, small batches of no larger than 1 cubic yard each.

(2) Equipment required comprises a watertight metal or wooden platform (about 10 feet x 12 feet), two shovels, 1-cubic-foot measuring boxes, mortar hoes, and pails for measuring water.

(3) Mix sand and cement dry first. If the batch consists of 2 sacks of cement, 5.5 cubic feet of sand and 6.4 cubic feet of coarse aggregate, 3 cubic feet of coarse aggregate and 3 cubic feet of sand are dumped on the platform first. Lay the sand out flat, and spread a sack of cement evenly over it. Then lay the rest of the sand and the other sack of cement similarly on the pile. Turn this mix two or three times until the material is a uniform color. After the cement and fine aggregate are mixed the pile is leveled off and the coarse aggregate is measured and spread over it. Then turn this batch two or three times and "trough" the center. Pour water, carefully measured, into the trough. Turn the dry materials into the water and mix until consistency is uniform.

b. **Handling Concrete.**

(1) Handling must be done in such a way that the mortar and aggregate do not separate.

(2) Equipment depends upon the job. On a small job requiring no lifts, transportation by buggy is the most economical. Sometimes chutes are necessary. Concrete can be carried in buckets to a higher or lower position. A crane derrick, cableway, or truck may be used to transport a bucket. Pumping may be the best method when space is too limited for buckets or buggies. Transportation over rough roads and dropping fresh concrete from excessive heights should be avoided. Excessive agitation during placing and vibrating should be avoided. More details on the pumping method may be found in TM 5-742.

58. PLACING AND CURING CONCRETE

a. **Basic Principles.** Good placing techniques result in a tight bond between the mortar and aggregate, and in the complete filling of the forms. The height of the drop is significant, a drop of more than 3 or 4 feet will cause segregation, and forms and concrete already placed will be damaged. For distances over 3 or 4 feet, concrete should be dropped through a vertical pipe. Deposit concrete in its final position as nearly as practicable. Do not deposit in a large quantity at one point. After concrete is placed, it must be cured and protected.

b. **Depositing Concrete.** Subgrades, forms, and steel reinforcing must be properly prepared and placed before placing the concrete.

(1) Rock. On rock subgrades the surface should be roughened and thoroughly cleaned. Remove water depressions and coat the rock surface with a ¾-inch layer of mortar containing only fine aggregate and a water-cement ratio the same as for concrete. It should have a 6-inch slump. Work the mortar in with stiff brushes.

(2) Clay. A fine-grained subgrade, such as clay, should be moistened to a 6-inch depth to help cure the concrete. Sprinkle the soil intermittently to prevent muddiness.

(3) Gravel and sand. Over gravel or other loose subgrades (not including compacted sand), lay tar paper or burlap. Lap the tar paper and staple. Join the burlap by sewing with wire, and sprinkle before concrete.

(4) Forms. Check the forms. They should be tight and clean, well braced, and coated. (See TM5-742 for oil coating procedure.)

(5) Depositing on hardened concrete. If concrete is to be placed on hardened concrete, the latter must be nearly level, clean, and moist. Remove any soft layer of mortar (called laitance) on the hardened concrete, and moisten the concrete. Dried-out concrete must be saturated for several hours, but be sure to leave no pools of water.

(6) Floor slabs. When building a floor slab in two courses, the lower course should be brushed with a stiff-fiber or steel brush before it sets. Clean and moisten this first layer before pouring the second layer.

(7) Wall construction.

(a) In wall construction, the inside form should be stopped off at the level of the joint. Overfill the form for about 2 inches and remove the excess just before setting occurs to insure a rough, clean surface. Before placing the next layer of concrete, deposit a ½- to 1-inch layer of sand-cement mortar, with the same water content as the concrete and a 6-inch slump.

(b) Deposit concrete in horizontal layers. Consolidate each layer before the next layer is placed. Place each layer in one operation. In mass work, the layer should be about 15 to 18 inches thick. In reinforced walls, it should be from 6 to 12 inches thick. As the walls are filled, remove the form spreaders.

(c) When placing concrete in tall forms, avoid dropping more than from 3 to 5 feet. Use a chute or tube instead. In this way the aggregate is not separated and the forms and reinforcing metal are not splashed with concrete which would harden prematurely before the main part of the concrete reaches the top level.

(d) When concrete is placed in tall forms at a rapid rate, there may be a bleeding of water to the top. Reduce the rate of placing and use a stiffer concrete.

(e) In high walls, place the concrete to within 1 foot of the top of the wall and allow an hour for settling. Resume pouring before set takes place. Over-fill the form by 2 to 3 inches and cut off the excess concrete after it has set a little so that the part of the form with higher water content is removed.

(8) Order of depositing concrete

(a) In walls and beams, the first batches should be placed at the end of a section. Place from there toward the center for each layer so water will not accumulate at the ends and corners.

(b) Place concrete at the far end of a slab and dump each batch against the previous one.

(c) Place concrete on slopes by depositing at bottom of slope first.

(9) Depositing concrete during rain. This involves protective measures. Use waterproof covering so rain is not mixed with concrete before it is set.

(10) Rate of placing. On large jobs, avoid excess pressure on forms by keeping the rate of fill at not over 4 feet per hour, measuring vertically, except for columns. An interval of at least 7 hours (preferably 24 hours) should elapse

between completion of columns and walls and placing of slabs, beams or girders supported by the columns.

(11) Expedient operations. Concrete is not a good material for temporary construction, it takes several days after being placed before it can be used. If emergency construction of temporary type is required, concrete may be placed in any manner with any equipment available. When forms are used, do not fill faster than 4 feet per hour.

c. Under Water. Concrete should be poured under water only when it is impracticable to do otherwise. Water should have a minimum temperature of 45°F. The velocity of flow should not be over 10 feet per minute, although socked concrete may be placed in water flowing at greater velocities. If water temperature is below 45°F, the temperature of the concrete should be above 60°F, but not above 80°F.

(1) Tremie method. A tremie is a pipe having a funnel-shaped upper end where concrete is fed. Figure 127 shows the device.

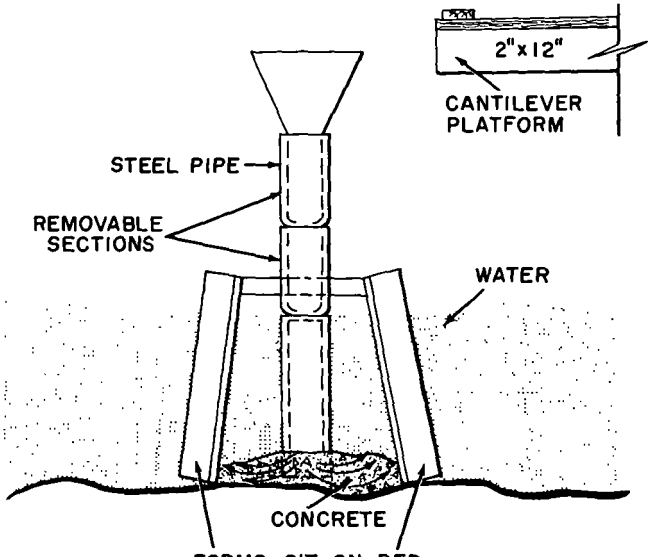


Figure 127. Placing concrete under water with a tremie

(o) Frequently the lower end of the pipe is equipped with a gate so that it may be filled before the concrete enters the water. The lower end of the pipe is kept continuously buried in newly placed concrete. With the pipe constantly filled with concrete, air and water are excluded. Lift the tremie slowly to allow the concrete to flow out. Do not lose the seal at the bottom, if the seal is lost, raise the tremie, plug the lower end, and lower into position again. Do not move tremie laterally through the deposited concrete. When time to move, lift the tremie out and move to desired position, keeping top surface of concrete as level as possible. For large area, use several tremies, spaced at 20- to 25-foot centers.

(b) Pumping from the mixer is the best way of supplying concrete.

(c) Large tremies can be suspended and handled from a crane boom

(d) Concrete poured through a tremie should have a slump of about 6 inches and a cement content of 7 sacks per cubic yard of concrete. About 50 percent of the total aggregate should be sand and the maximum coarse aggregate size from 1½ to 2 inches.

(2) Concrete buckets. Concrete can be placed at considerable depth into the water by open-top buckets with a drop bottom. Make the concrete slightly stiffer than that placed by tremie. Mixture should be same-- 7 sacks of cement per cubic yard of concrete. Fill the bucket and cover the top with canvas flap. Lower slowly into the water so as not to displace the flap. Discharge the concrete on reaching the surface where it is to be placed.

(3) Sacked concrete. Concrete can be placed under water in sacks in an emergency. Jute sacks of about 1-cubic-foot capacity, filled about two-thirds full, are lowered into the water, preferably shallow water. Place the sacks in header and stretcher courses, interlocking the entire mass. A header course is placed so that the length of the sack is at right angles to the direction in which the stretcher-course sacks are laid. Sacks are bound together because the cement from one sack seeps into adjacent sacks. Do not use sugar sacks, sugar is harmful to concrete. Do not try to compact this concrete under water, the less it is disturbed the better.

d. **Consolidating Concrete.** Excepting concrete placed under water, all concrete is worked into place by spading, by puddling, or by mechanical vibrators. Consolidation eliminates rock pockets and brings fine material to the surface. Work concrete carefully around all reinforcing steel.

(1) Vibration. Mechanical vibrators are effective in consolidation.

(a) Vibration makes it possible to place mixtures so stiff to be placed in any other way; concrete with only a 1- or 2-inch slump may be deposited. Less cement is required, and there is less danger of segregation and the working of water toward the top.

(b) Both external and internal vibrators are available, the former are applied to the forms and the latter into the concrete. They are powered. Internal vibrators should be inserted at points about 18 inches apart. Vibration continues until a thin line of mortar appears along the form and when the coarse aggregate has sunk. *Do not overvibrate.* Do not vibrate concrete if it has a slump of 5 or 6 inches. Hand spading should be used along with the vibrator.

(2) Spading (puddling). Spading should continue until the coarse aggregate disappears into the mortar.

e. **Curing and Protection.**

(1) Moist curing. The loss of moisture must be prevented during hydration. Keep the exposed surface moist by spraying or ponding, or covering with earth, sand, or burlap, maintained in a moist condition.

(2) Curing compounds. Remove the forms and spray on the compound in 1 coat. Do not use the compounds if the air temperature is above 100°F and the air is dry.

(3) Protection against low temperatures. Do not let the temperature of fresh concrete fall below 40°F.

CHAPTER 7

ROADS AND AIRFIELDS

Section I. ROADS

59. MINIMUM DESIGN REQUIREMENTS

Table 64 gives a summary of military road specifications.

60. TYPES OF SURFACES

a. **Earth Roads.** Earth roads consist of native fine-grained soils, graded and drained to form a surface for carrying traffic. Their use is limited to dry weather and light traffic. In combat areas these roads are used where necessity demands speed of construction with limited equipment and personnel.

b. **Oiled Earth Roads.** Oil is spread on earth roads to prevent dust and help waterproof the surface. It is successful with silt or clay. The amount of oil used varies from about ½ to 1 gallon per square yard applied in two or three increments, depending upon the soil and the type of oil used.

c. **Soil-Stabilized Surfaces.** Bituminous soil-stabilized mixtures and soil cement may be used as road surfaces as an expedient for relatively short periods and to carry light traffic.

d. **Sandy-Clay Roads.** This type of road has a natural or artificial mixture of sand and clay, graded and drained to form a road surface. Usually fine gravel added to it will give stability. These roads serve well for light traffic, and will carry heavy traffic except in adverse weather, although they withstand such conditions better than earth roads.

e. **Gravel Roads.** Gravel roads are a compacted layer of well graded gravelly soil which meets the plasticity requirements for mechanically stabilized soils. Grading requirements for this type of surface are given in table 65. Natural pit- or bank-run gravel may meet these requirements with only screening. Other pit- or bank-run gravel may require both screening and washing. River gravels normally require the addition of binder soil. The capability of gravel roads to carry heavy, sustained traffic depends on the strength and hardness of gravel, the cohesiveness of clay binder, the thickness of the layer, and the stability of the subgrade. These surfaces make an excellent base for later pavements.

f. **Roads of Processed Materials.** Processed materials are prepared by crushing and screening rock, gravel, or slag. The information on gravel roads is applicable to these roads. They should meet the grading requirements set forth in table 66.

g. **Use of Calcium Chloride and Sodium Chloride.**

(1) Calcium chloride is widely used in construction (and maintenance) of mechanically stabilized soil surfaces, gravel roads, and roads made with composite type processed materials. Calcium chloride attracts and retains

Table 64. Military Road Specifications

Characteristic	Specification
Width	
Traveled way (single lane)	Min - 12 ft (3.5 meters)
Traveled way (two lanes)	Min - 22 ft (6.5 meters)
Shoulders (each side)	Min - 4 ft (1.5 meters)
Clearing	Min - 6 ft (2 meters) on each side of roadway
Alinement	
Grades:	
Absolute maximum	Lowest maximum gradability of vehicles for which road is built
Normal maximum	10%
Desirable maximum	Tangents and gentle curves, less than 6% sharp curves, less than 4%
Horizontal curve radius	Desired min – 150 ft (45 m); Absolute min - 80 ft (25 m)
Vertical curve length:	
Invert curves	100-ft min (30 m) for each 4% algebraic difference in grades
Overt curves	125-ft min (40 m) for each 4% algebraic difference in grades
Sight distance:	
Nonpassing	Absolute minimum - 200 ft (60 m)
Passing	Absolute minimum - 350 ft (110 m)
Load capacity	
Road proper	Sustain 10,000-lb wheel load
Bridges	Accommodate using traffic
Slopes	
Shoulders	¾ in per ft
Crown (gravel and dirt)	½ to ¾ in per ft
Crown (paved)	¼ to ½ in per ft
Superelevation	¼ to 1-¼ in per ft
Cut	Variable
Fill	Variable
Drainage	
Good	Adequate crown or superelevation with adequate ditches and culverts in good condition. Take full advantage of natural drainage. Try to locate road at least 4 ft above the ground-water table

Table 64. Continued

Characteristic	Specification
Miscellaneous	
Overhead clearance	Min - 16 ft (5 m)
Traffic volume	2,000 vehicles per day
Turnouts (single lane)	Min - every ¼ mile

Table 65. Suggested Grading Requirements for Gravel and Composite Type Surface Courses of Processed Materials

Sieve designation	% passing, by weight
1 in	100
3/4 in	85 - 100
3/8 in	65 - 100
No. 4	55 - 85
No. 10	40 - 70
No. 40	25 - 45
No. 200	0 - 10

moisture from the air. Use 0.5 pound per square yard per inch of compacted mixture when mixed-in-place construction is used. If the mixture is prepared at a central plant, the mixture should be 10 pounds of calcium chloride per ton of mixture. It is recommended that 1 pound per square yard be applied when the surface is complete.

(2) Sodium chloride (generally rock salt) may be used in much the same way as above. Use about 1 ton per mile per inch of compacted surface 20 feet (6 meters) wide.

h. **Other Aggregate Materials.**

(1) Coral. Coral requires considerable maintenance because it will scar and rut when given hard usage, causing water to pond and soften the base. Surfaces must be periodically shaped with a grader. Traffic will also produce a fine dust, which requires periodic sprinkling, preferably with salt water.

(2) Caliche. The life of caliche (a hard pan, cemented by mineralizing solutions) is greatly increased as a surface when bituminous treatment is applied.

(3) Tuff. Tuff (deposits of fine minerals ejected by volcanoes) is dusty when

Table 66. Suggested Grading Requirements for Coarse-Graded Type Surface Course of Processed Materials

Sieve designation	% passing, by weight
¾ in	100
No. 4	70 - 100
No. 10	35 - 80
No. 40	25 - 50
No. 200	8 - 25

dry and slippery when wet. Regarde and roll the surface after a rain to hold surface moisture and close cracks. An asphalt seal coat will prevent infiltration of water.

i. **Ice Surfaces.** In northern latitudes, vehicles and aircraft may use the surfaces of fresh-water ice on lakes and rivers, or salt-water ice on seas or along coastlines.

(1) Fresh-water ice breaks up in the spring. During the winter the strength of this ice exceeds that of young sea ice. The strength of sea ice increases with time, and has a use equal to fresh-water ice when thick enough.

(2) Ice strength is affected by temperature and its condition. Inspect the condition of ice carefully for honeycomb, rotting, or melting before imposing heavy loads.

(3) Snow and ice roads are satisfactory for traffic use where the snowfall reaches a minimum of 2 feet and the temperature falls to below 20°F for at least 3 months. Four types of snow and ice roads are: pioneer, trough, and wide and narrow rut. See TM 5-349 for their construction. A pioneer snow road carries cargo vehicles or snow tractors with gross weights up to about 5,000 pounds. A trough road supports 2½-ton trucks and medium track-type tractors with sled trains. A wide-rut road supports 6-ton trucks and heavy track-type tractors with sled trains. However, over ice the bearing capacity depends on the ice thickness. Table 67 is a rule-of-thumb guide to the load capacity of ice.

j. **Portable Road Surfaces.** During operations in the field it is often necessary to make temporary use of metal mesh, metal landing mats, wood mats, or various types of treadways. These materials are rapidly transported and assembled over mud, swamps, beaches, or other unstable soils. TM 5-330 gives the details of constructing portable surfaces.

Table 67. Load Capacity of Ice

Load	Minimum thickness of ice, in	Minimum interval ft
Single riflemen on skis or snowshoes.	1½ (40 mm)	16 (5 m)
Troops in single file, 2-pace distance	3 (80 mm)	*23 (7 m)
Troop column, single horses, motorcycles, unloaded sleds, or motor-toboggons	4 (100 mm)	*33 (10 m)
Single light artillery piece, ¼-ton truck, 4 x 4	6 (150 mm)	49 (15 m)
Light artillery, passenger cars, medium 1½-ton trucks with gross weight of 3½ tons	8 (200 mm)	65 (20 m)
2½-ton trucks, light loads	10 (250 mm)	82 (25 m)
Closed columns of all arms except armored force and heavy artillery	12 (305 mm)	*98 (30 m)
Armored scout cars, light tanks	14 (355 mm)	115 (35 m)
20-ton vehicles	16 (405 mm)	131 (40 m)
45-ton vehicles	24 (60 cm)	164 (50 m)

* Minimum interval between files or columns.

61. CROSS SECTIONS

A cross section is a transverse section of a road taken at right angles to the horizontal projection of the road's centerline. The cross-sectional shape of the subgrade depends upon the surfacing to be used (figs. 128 through 132). The subgrade on earth roads is shaped to the standard road cross section. If surfaced, the subgrade is graded to the same slope as the finished surface. With the trench method, the earth which is excavated to form a trench is pushed to the sides of the road to form retaining shoulders.

62. SOILS

a. **Control of Soils.** The military engineer must know how to evaluate existing or potential soil conditions, to predict soil behavior under varying conditions, and to reach satisfactory solutions to the problems dealing with foundations and earthwork construction which he encounters in military operations. The control of soils encompasses the formation and characteristics of soils, their classification, the movement of water, frost action, the compressibility and shearing resistance of soils, bearing capacity, and the compaction and stabilization of soils.

b. **Hardness.** The crust of the earth is composed of a variety of solid materials. The most common is *rock*, which is composed of minerals. The hardness of a mineral is a measure of its ability to resist abrasion. The following scale is a list in order of increasing hardness:

Talc, or mica	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Feldspar	6
Quartz	7
Topaz, or beryl	8
Corundum	9
Diamond	10

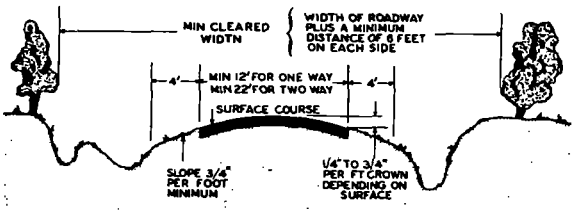

MIN CLEARED WIDTH
WIDTH OF ROADWAY PLUS A MINIMUM DISTANCE OF 6 FEET ON EACH SIDE
4'
MIN 12' FOR ONE WAY
MIN 22' FOR TWO WAY
4'
SURFACE COURSE
SLOPE 3/4" PER FOOT MINIMUM
1/4" TO 3/4" PER FT CROWN DEPENDING ON SURFACE

Figure 128. Typical cross-section illustroting rood specifications.

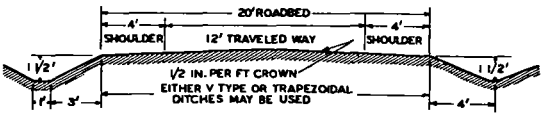


Figure 129. One-way earth rood.

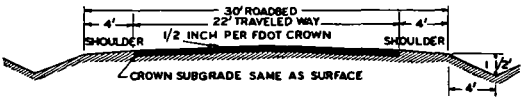


Figure 130 Two-way rood using single-course construction.

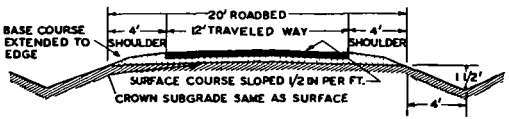


Figure 131. One-woy rood using double-course construction.

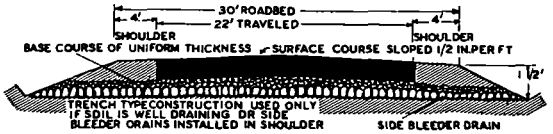


Figure 132. Two-woy rood using double-course, trench-type construction.

c. **Field Expedients for Soil Analysis.** The following field tests may be of value in soil analysis.

(1) Feel. Sand has a gritty feel when rubbed between the fingers. Dry silts have a smooth, silky, floury feel. Some wet clays feel slick or soapy. Very light or very heavy soils feel very light or very heavy in weight.

(2) Shine. When rubbed with fingernail or knife blade, inorganic clays remain dull, high plastic clays become shiny.

(3) Taste. Fine-grained soil will tend to stick to tongue.

d. **Drainage Characteristics.** Soils may be divided into three general groups on the basis of their drainage characteristics:

(1) Well-draining soils. Clean sands and gravels fall into this classification. They may be readily drained by gravity systems. For roads or airfields, open ditches may be used in these soils to intercept and carry water.

(2) Poorly draining soils. These are the inorganic and organic fine sands and silts, organic clays of low compressibility, and coarse grained soils having an excess of nonplastic fines. Drainage by gravity alone is difficult in these soils.

(3) Impervious soils. Fine-groined, homogeneous, plastic soils, and coorse-grained soils containing plastic fines are in this category. Subsurface drainage is so slow in these soils that it is of little value in improving their condition. Any drainage process may be difficult and expensive.

63. DRAINAGE

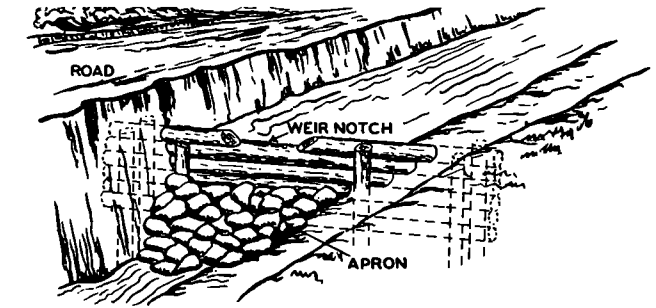
a. **Check Dams.** Check dams are used on sidehill cuts and steep grades, where they are placed in side ditches to slow the water and prevent it from washing out the road. Check dams are not used when the ditchline grade exceeds 5 percent or where erosion is a problem. They are made of timber, sandbags, concrete rock, or similar materials. *Figure* 133 shows the method of computing check dam spacing.

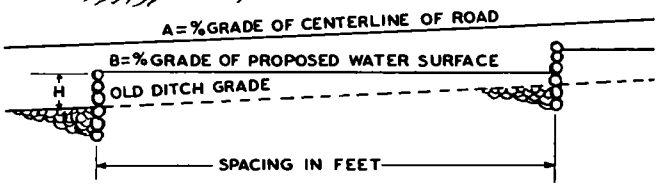
b. **Culverts.** Culverts are required wherever drainage channels are needed to cross roads, to provide ditch relief, and to continue side ditches at the intersections or road and access routes. In tactical situations where roads will be used only a few weeks, the cross-sectional areas of drainage facilities are estimated by hasty methods.

(1) Talbot's formula may be used as an approximate method for computing the cross-sectional area of a proposed culvert. This formula is:

$$A = C\sqrt[4]{D^3}, \text{ or } A = CD^{3/4}$$

where A = area of waterway opening in square feet
D = drainage area in acres
C = coefficient of retardation based upon slope, soil characteristics, and shape (see table 68).





$$\text{SPACING} = \frac{100\ H}{A-B}$$

H IS EXPRESSED IN FEET

Figure 133. Methods of computing checkdam spacing.

(2) Toble 69 shows required culvert openings as computed from Talbot's farmula.

(3) An alinement chart far solutions is given in figure 134.

(4) The deliberote method of estimoting runoff cambines engineer judgment with calculotions based on anolysis, measurement, or estimatian. It is expressed by:

$$Q = CIA$$

where Q = runoff from o given areo in cubic feet per second
C = o coefficient representing the rotio af runoff ta roinfoll
I = intensity of roinfoll in inches per hour for the estimated time af concentration
A = droinoge oreas in acres

The value of C is derived from a study of the soil, the slope, and conditions of the surface. The more commonly used values are shown in table 69. Other formulas may be found in TM 5-335.

c. **Culvert Placement.**

(1) A way to prevent erosion is pointed out in figure 135. Suggestions on their alinement are shown in figure 136.

(2) Culverts are normally at the grade of the natural and artificial drainage channels which discharge into them. Grades of 2 to 4 percent are desirable. Velocities should not be over 8 feet per second nor less than 2.5 feet per second.

(3) Culverts should be placed wherever natural drainage channels require cross-drainage. Figure 137 shows the spacing of ditch-relief culverts. The bedding and spacing of multiple-pipe culverts is equal to at least half the diameter of the pipe (fig. 138).

d. **Box Culverts.** There are several types of box culverts; log box, timber box, and concrete box. Examples of each are shown in figures 139 through 141.

e. **Nestable Corrugated Pipe Culverts.** These culverts are of two types: notched, having a notched edge and plain edge: and flanged, having flanges with slotted holes. The two types are not interchangeable. Figure 142 shows the strutting diagram for assembling the corrugated pipe.

Table 68. Surface Runoff Factors

Types of surface	Factor
Bituminous pavements.	0.80 to 0.95
Concrete pavements.	0.70 to 0.90
Gravel or macadam pavements . .	0.35 to 0.70
Impervious soils	0.40 to 0.65
Impervious soils, with turf* . . .	0.30 to 0.55
Slightly pervious soils*	0.15 to 0.40
Pervious soils*	0.01 to 0.10
Wooded areas (depending on surface slope and soil cover)	0.01 to 0.20

* For slopes from 1 to 2 percent.

Table 69. Required Culvert Opening, in Square Feet, Computed from Talbot's Formula

Drainage area in acres	Mountainous (C = 1.0)	Hilly (C = 0.7)	Rolling (C = 0.5)	Flat (C = 0.2)
2	1.7	1 2	0.9	0.3
5	3 3	2.3	1.7	0.7
10	5.6	3 9	2.8	1.1
20	9.5	6.7	4.8	1 9
30	12.8	9.0	6 4	2.6
40	15.9	11.1	8 0	3.2
50	17.8	12.5	8.9	3.6
75	25.4	17.8	12.7	5.1
100	31.6	22.1	15.8	6.3
150	42.9	30.0	21.5	8.6
200	53.1	37.2	26.6	10.7
300	72.2	50.5	36.1	14.4
400	88.1	61 7	44.1	17.6
500	106.0	74.2	53.0	21.2
600	121 0	85.0	61 0	24.0
800	151.0	106.0	76.0	30 0
1,000	178 0	125.0	86.0	36 0
1,200	204.0	143 0	102.0	41.0
1,500	241 0	169.0	121.0	48.0
2,000	299.0	209.0	150.0	60.0
2,500	353.0	247.0	177.0	71.0
3,000	(*)	284 0	203 0	81.0
4,000	(*)	352.0	252.0	101 0
5,000	(*)	(*)	298.0	119.0
7,500	(*)	(*)	(*)	161.0
10,000	(*)	(*)	(*)	200.0
15,000	(*)	(*)	(*)	271.0
20,000	(*)	(*)	(*)	336.0

* Formula not to be used for these conditions.

NOTE: Value of C may be reduced where ponding or temporary storage is available, such as in irrigated areas or rice paddies.

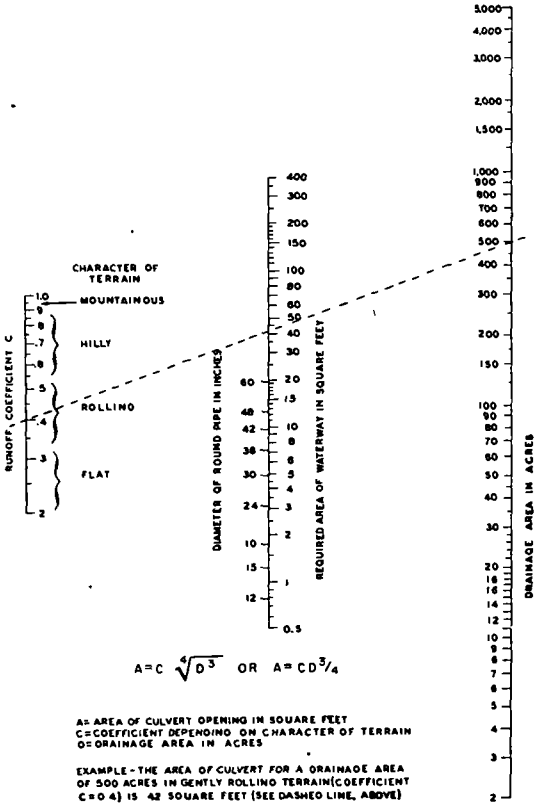

CHARACTER OF TERRAIN
MOUNTAINOUS
HILLY
ROLLING
FLAT
RUNOFF, COEFFICIENT C
DIAMETER OF ROUND PIPE IN INCHES
REQUIRED AREA OF WATERWAY IN SQUARE FEET
DRAINAGE AREA IN ACRES
A=C $\sqrt[4]{D^3}$ OR A=CD$^{3/4}$
A= AREA OF CULVERT OPENING IN SQUARE FEET
C=COEFFICIENT DEPENDING ON CHARACTER OF TERRAIN
D=DRAINAGE AREA IN ACRES
EXAMPLE - THE AREA OF CULVERT FOR A DRAINAGE AREA OF 500 ACRES IN GENTLY ROLLING TERRAIN (COEFFICIENT C=0.4) IS 42 SQUARE FEET (SEE DASHED LINE, ABOVE)

Figure 134. Alinement chart for solution of Talbot's formula.

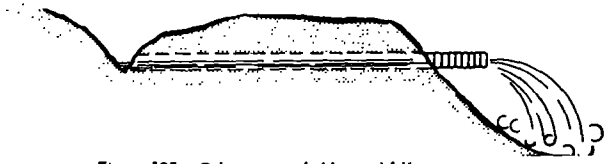


Figure 135. Culvert extended beyond fill to prevent erosion.

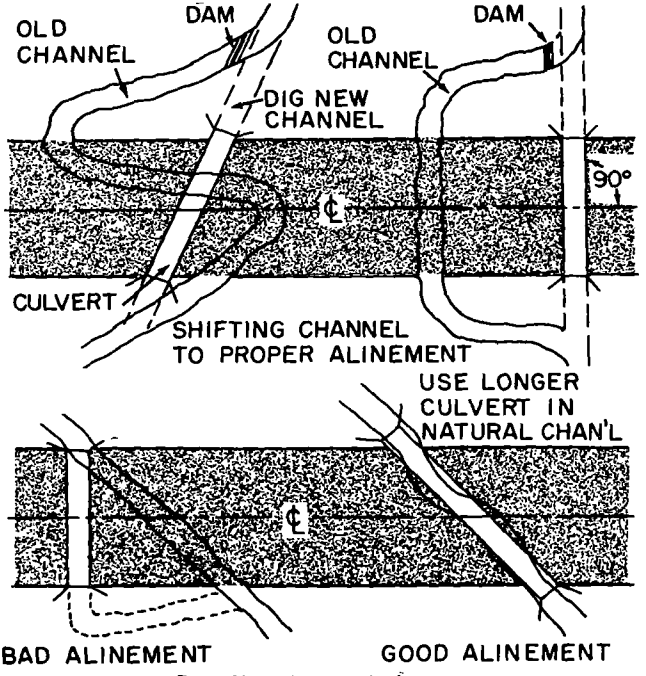


Figure 136. Alinement of culverts.

f. ***Expedient Culverts.***

(1) *One type of this culvert uses oil, gasoline, or aspholt drums. Remove their ends with detonating cord, sharp hand tools, or the toal-pneumatic metol drum opener.*

CAUTION: *Da not use o torch ar other tools an gasoline or oil drums unless they are completely empty. Join these drums end to end by tack-welding, bolting, or wiring* (fig. 143).

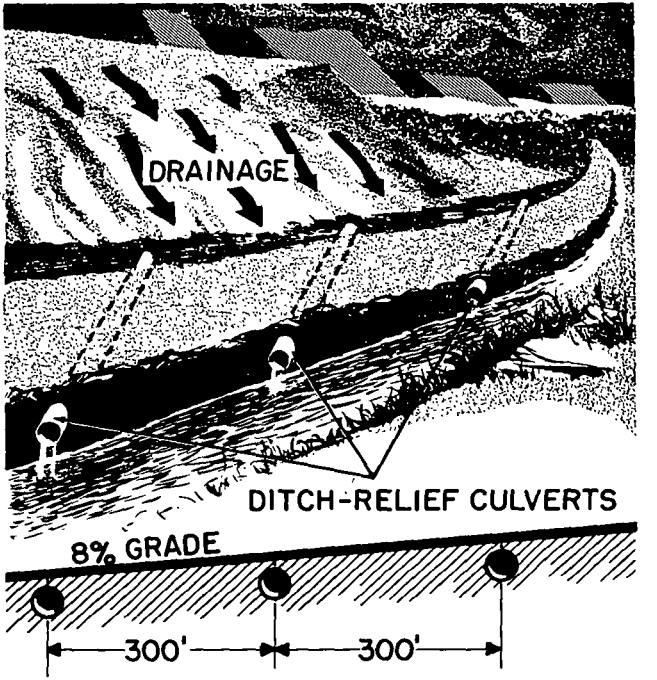


Figure 137. Spacing of ditch-relief culverts.

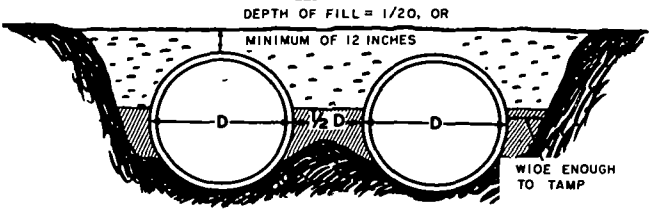


Figure 138. Spacing of multiple-pipe culvert.

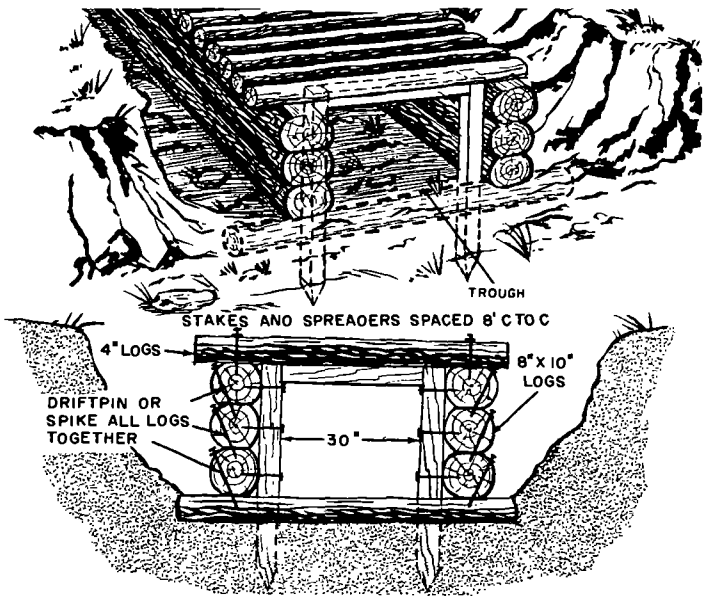


Figure 139. Log culvert, 30-inch.

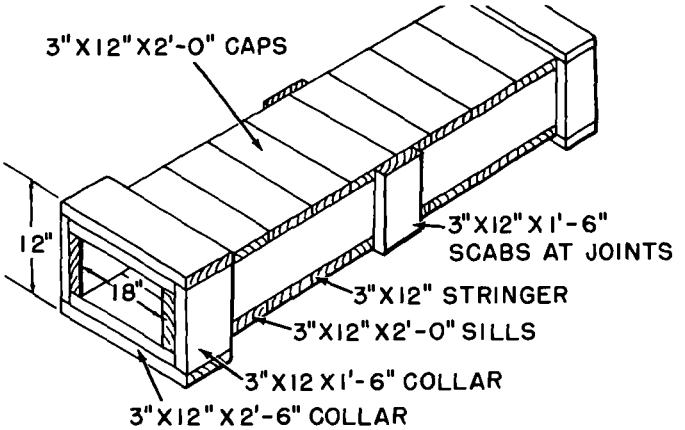


Figure 140. Timber box culvert, 18- by 12-inch.

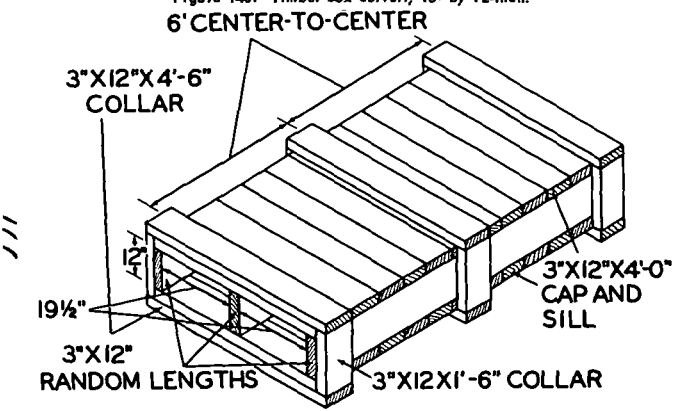


Figure 141. Timber box culvert, 19½- by 12-inch.

(2) Another type of expedient culvert is also illustrated in the lower part of figure 143 It uses sandbags and pierced metal panels, the latter being placed both above and below the sandbags as shown in figure 143

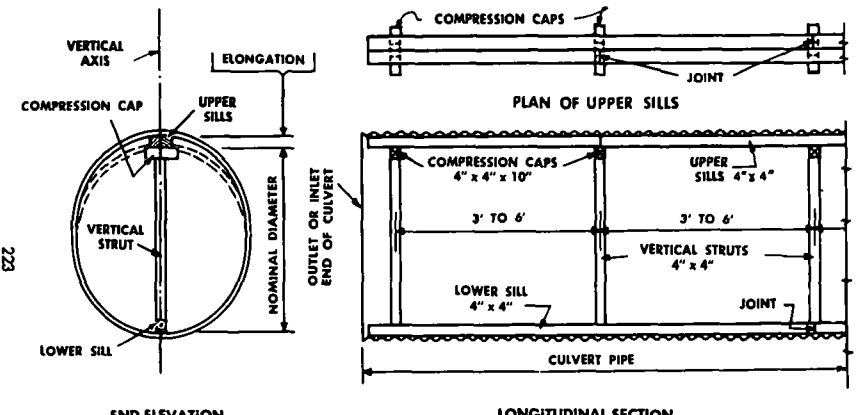
g. **Cover.** A minimum cover requirement of ½ the diameter can be used for reinforced concrete pipe and corrugated metal pipe culverts. Culverts other than pipe should have a minimum of 12 inches, preferably 18 inches, of cover. Where heavy equipment is used in construction, adequate cover must be provided to protect culvert structures from damage.

64. EARTHMOVING EQUIPMENT

a. **Output.** Table 70 is written to give much of the required data for the small-unit leader concerning average dozer earth-moving capabilities.

b. **Formula.**

(1) For the purposes of small-unit operations, the following formula may be used in situations wherein table 70 would not be applicable.



NOTE· CULVERTS 60" TO 72" IN DIAMETER SHALL BE ELONGATED 2" ALONG THE VERTICAL AXIS DIMENSION. CULVERTS 84" IN DIAMETER SHALL BE ELONGATED 2½".

Figure 142. Strutting diagram showing end and longitudinal views.

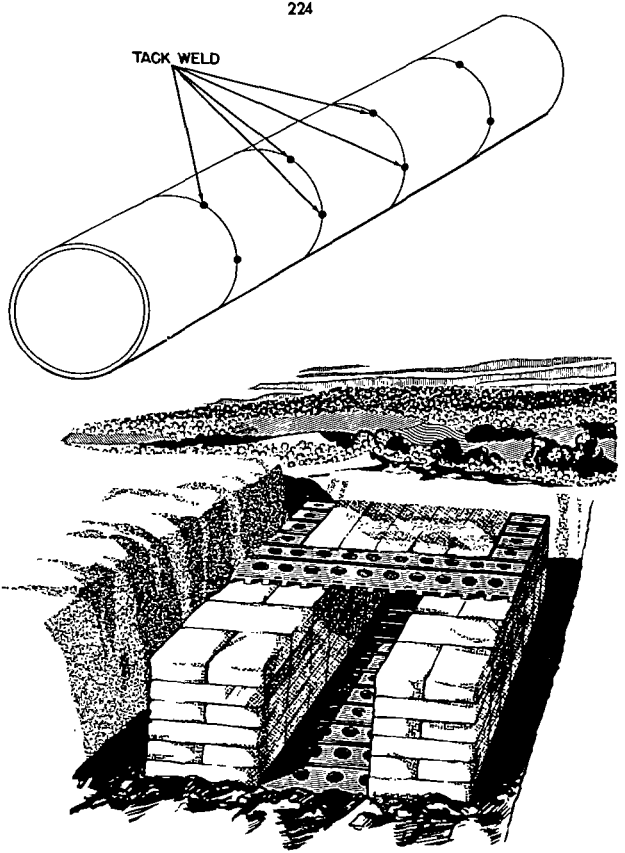
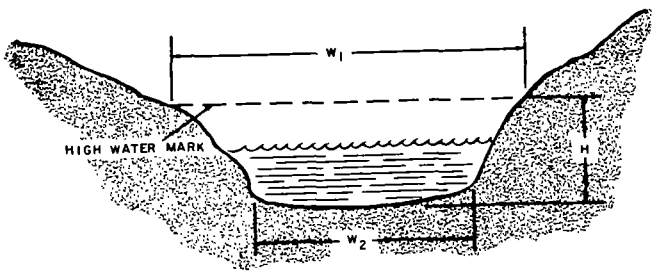


Figure 143. Expedient culverts.



W_1 = WIDTH OF CHANNEL AT HIGH WATER MARK

W_2 = WIDTH OF CHANNEL AT BOTTOM

H = VERITICAL DISTANCE FROM BOTTOM TO HIGH WATER MARK

$\left(\frac{W_1 + W_2}{2}\right) H$ = AREA OF WATERWAY

SIZE OF CULVERT = AREA OF WATERWAY + SAFETY FACTOR 100%

Figure 144. **Hasty culvert.**

(2) Taking a push distance of 300 feet for the D8 dozer, the problem could be worked as follows:

$$\underset{\text{Push}}{\frac{300 \text{ ft}}{2.3 \times 88 \text{ ft/min/mph}}} + \underset{\text{Return}}{\frac{300 \text{ ft}}{3.7 \times 88}} + \underset{\text{Fixed time}}{0.20} =$$

$$\frac{300}{202.4} + \frac{300}{325.6} + 0.20 =$$

$$1.48 + 0.92 + 0.20 = 2.60$$

Therefore, total cycle time = 2.60 minutes

The number of trips per hour would = $\frac{60 \text{ min/hr}}{2.60}$

Trips/hr = 23.07

Table 70. Dozer Output

Model	Capacity in yds (loose)	Production rate per hr, in yds		Speeds in mph		Gal of fuel per hr
		50-ft haul	100-ft haul	Forward (2nd gear)	Reverse (3rd gear)	
D8	5.0	450	250	2.3	3.7	11 (DSL)
D7	4.1	390	315	2.2	5.4	10 (DSL)
D6	2.6	284	154	2.9	4.2	9 (DSL)
TD - 18	(Same data as for D7)			2.1	3.4	10 (DSL)
TD - 24	(Same data as for D8)			2.6	8.0	11 (DSL)
LeTourneau Super C Tournadozer	5.0	364	272	3.69	8.38	12 (DSL)

NOTE: These figures will vary with percent of grade, weather conditions, elevation, experience of the work crew, type of soil, and length of haul. In checking grade resistance, use GR (or GA) = total weight (in tons) x 20 lbs/ton x units of percent grade. For altitudes above 3,000 feet, a 3% horsepower loss is encountered for each 1,000 feet thereafter. Regarding each type of soil, see the soil conversion factor in table 77. Bowl capacities given are for common earth (loam, sand, and clay mixture) in loose cubic yards.

Since the number of yards moved per trip is 5 (table 70), we have $23.07 \times 5 \times 0.83 = 95.74$ yds per hr of loose soil. For 0.83, see table 72.[3]

To convert this into bank yards, multiply this answer by 0.80 (the load, or soil, factor given in table 71, column 4):

$95.74 \times .80 = 76.59$ bank yds/hr

NOTE: [1]The 88 is derived from 5280 ft/mile divided by 60 to get ft/min.
[2]This is the basic fixed time for a tracked dozer when another gear is used on return trip.
[3]Efficiency factor from table 72.

c. **Pertinent Data.** Tables 71 and 72 give the data necessary to work the formula in b, above.

Table 71. Approximate Material Characteristics*

Material	Lbs per cu yd, bank	% of Swell	Load (or soil) (conversion) factor	Lbs per cu yd, loose
Cinders	1,200	40-50	.72-.65	780-860
Clay, dry	2,700 to	40	.72	1,950 to
" wet	3,500	40	.72	2,500
Coal, anthracite	2,600	35	.74	1,900
" bituminous	2,250	35	.74	1,650
Earth (loam or silt):				
dry	1,700 to	15-35	.87-.74	1,250 to
wet	3,500	25	.80	2,800
Gravel, dry	2,450 to	10-15	.87-.74	1,250 to
" wet	3,900	10-15	.91-.87	3,550
Gypsum	4,300	30	.77	3,300
Iron ore	4,600	18	.85	3,900
Limestone	4,400	65	.60	2,650
Sand, dry	2,200-3,400	10-15	.91-.87	1,900-3,100
" wet	2,450-3,900	10-15	.91-.87	2,150-3,550
Sandstone	4,000	65	.60	2,400
Shale (soft rock)	4,400	65	.60	2,650
Troprock	5,000	50	.66	3,300

* The weight and load factor of material will vary with such factors as grain size, moisture content, and degree of compaction. If an exact material weight must be determined, then a test must be run on that particular sample.

Table 72. Dozer Efficiency Factors

Time of operation	Tractor type	Working hrs	Eff. factor
Day	Track	50 min/hr	0.83
	Wheel	45 min/hr	0.75
Night	Track	45 min/hr	0.75
	Wheel	40 min/hr	0.67

65. CONSTRUCTION ESTIMATES

a. **Cubic Yards, Loose Measures, Gravel or Crushed Rock Required per Linear Unit of Road.** This information is contained in table 73.

b. **Linear Feet of Spread per Cubic Yard of Gravel or Crushed Rock to Produce Required Thickness.** Table 74 shows that data.

c. **Gallons of Bitumen Required.** Table 75 specifies the total number of gallons of bitumen per mile required at various rates of application per square yard.

d. **Productive Capacity of Labor and Equipment.** Table 76 gives the productive capacity of various items of equipment when used in construction and maintenance operations. This information should be used only as a guide, refer to TM 5-252 for detailed methods of estimating the work output of various items of equipment.

Table 73. Gravel or Crushed Rock Required per Linear Unit of Road in Cubic Yards, Loose Measure

Width, ft	Thickness		Length of road section		
	In.	Condition*	100 ft	100 yds	1 mi
10	1	Loose	3.09	9.26	162.9
		Compacted	3.86	11.57	203.6

* Ratio of loose thickness to compacted thickness assumed to be 1.25.

Example: Quantity required for 4-in compacted course on 350 yds of road, 22 ft wide, is:

$$Q = 11.57 \times \frac{22}{10} \times \frac{4}{1} \times \frac{350}{100} = 356.4 \text{ cubic yards, loose measure.}$$

Table 74. *Linear* Feet of Spread per Cubic Yard of Gravel or Crushed Rock to Produce Required Thickness

Thickness of surface, in.	Condition	Width of roadway, ft		
		12	22	30
1	Loose	27.0	14.7	10.8
	Compacted	21.6	11.8	8.6
3	Loose	9.0	4.9	3.6
	Compacted	7.2	3.9	2.9
4	Loose	6.7	3.4	2.7
	Compacted	5.4	2.9	2.1
6	Loose	4 5	2.4	1.8
	Compacted	3.6	1.9	1.4

Example: Length of spread for 2½-cubic-yard truck to produce 4-inch compacted thickness 22 feet wide is: $L = 2.9 \times 2.5 = 7.25$ feet.

Table 75. Gallons of Bitumen Required for 1 Mile of Road

Gals per sq yd	Road widths, ft		
	9	12	20
		Total gals	
0.25	1,320	1,760	2,933
0.50	2,640	3,520	5,867
1.00	5,280	7,040	11,733
1.50	7,920	10,560	17,600

66. IDENTIFICATION OF BITUMINOUS MATERIALS

a. **Asphalt and Tar.** Asphalt and tar products are the principal bituminous materials used for road and airfield construction. Figure 145 is a field guide to identification of unknown bituminous materials. Table 77 shows the few grades which may be manufactured in the field.

b. **Asphalt Construction.** For emergency use, mix-in-place surfaces are made of 3.5 to 6 percent bitumen, depending on the fineness of aggregate. (See TM 5-337 for procedures.)

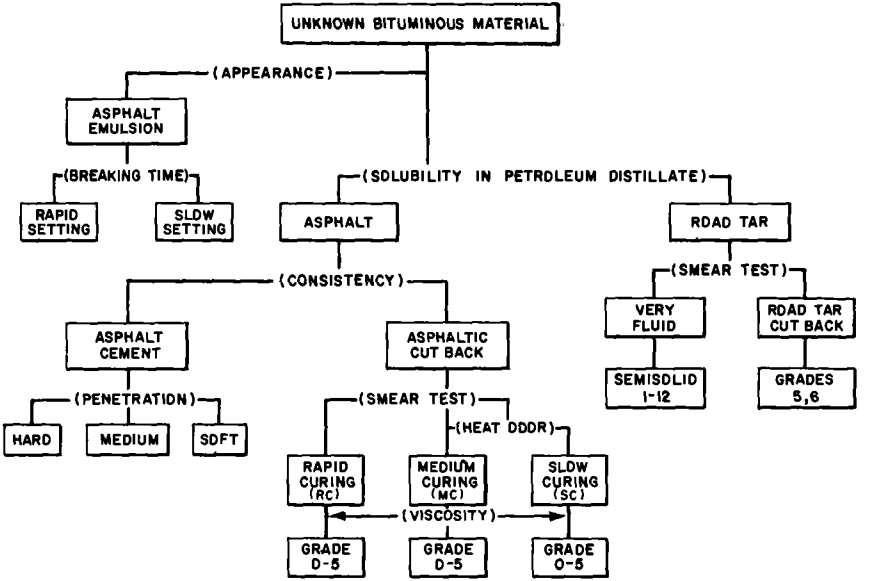


Figure 145 Chart to be used in the field identification of unknown bituminous materials.

Table 76. Productive Capacity of Equipment

Equipment	Rate units per hr	Unit	Conditions
DRAINAGE DITCHES			
Grader, motorized	250	cu yd	V-ditches, easy digging
	150	cu yd	V-ditches, med. hard digging
	85	cu yd	V-ditches, hard digging
Shovel or dragline, 3/4 cu yd	60*	cu yd	Hard digging
	125*	cu yd	Easy digging
Hand tools	5 man-hrs	100 ft	V-ditches, 3 ft wide, 1 foot deep, easy digging
	9 man-hrs	100 ft	V-ditches, 3 ft wide, 1 foot deep, medium hard digging
Ditching machine, ladder type	0-8	ft. per min.	Operating speed depends on width (18 or 24 in.), depth (0 to 99 in.), and type of soil
Ditching machine, mobile	0-28	ft. per min.	Same as above, except 24 in. wide
CLEARING AND GRUBBING			
Hand tools	1½ man-hrs	tree	3 man blasting team, good conditions
	125 man-hrs	acre	Light clearing
	350 man-hrs	acre	Medium clearing
	25 man-hrs	100 lin yd	Light clearing, 30 ft wide
	70 man-hrs	100 lin yd	Medium clearing, 30 ft wide
Mower, with tractor, 30-dbhp	2.0	acre	Cutting weeds and grasses
Tractor, 66- to 90-dbhp, with dozer	1.0	acre	Light stripping or clearing
	0.25	acre	Medium clearing
	20 to 50	trees	4 in. to 10 in. diameter
	3 to 12	trees	12 in to 30 in. diameter
GRADING			
Tractor, 66- to 90-dbhp, with dozer	400	lin ft	Sidehill cut, medium-hard digging, 10° slope
	190	lin ft	Sidehill cut, medium-hard digging, 20° slope

Table 76. Continued

Equipment	Roto units per hr	Unit	Conditions
GRADING—Continued			
Tractor, 66- to 90-dbhp, with dozer--continued	110	lin ft	Sidehill cut, medium hard digging, 30° slope
	120	cu yd	Sidehill cut, medium hard digging
	90	cu yd	Sidehill cut, hard digging
	130	cu yd	50 ft level haul, medium hard digging
	80	cu yd	100 ft level haul, medium hard digging
Scraper, towed 12 cu yd with tractor	145	cu yd	500 ft level haul, medium hard soil
	121	cu yd	800 ft level haul, medium hard digging
Shovel, power, ¾ cu yd	45	cu yd	Hard digging
	75	cu yd	Easy digging
Grader, motorized	0.2	mile	Digging side ditches and shaping crown, 4 round trips
Hand tools	1.2 to 2.4	cu yd	Loading loose material into truck, 1 man with shovel
	1.5	cu yd	Excavation with pick and shovel, to 5 ft, easy digging
EMBANKMENT			
Tractor, 70 - to 90-dbhp, with angle-dozer	300	cu yd	Spreading material
Roller, sheepsfoot,	250	cu yd	9 in loose layers, 8 passes
two drum-in-line,	200	cu yd	9 in loose layers, 10 passes
towed by tractor, 70- to 90-dbhp	150	cu yd	9 in loose layers, 12 passes
SUBGRADE PREPARATION			
Grader, motorized	400	sq yd	Scarify and shape

Table 76. Continued

Equipment	Rate units per hr	Unit	Conditions
SUBGRADE PREPARATION–Continued			
Roller, sheepsfoot, two drum-in-line, towed by tractor, 70- to 90-dbhp	650 540 450	sq yd sq yd sq yd	6 in layers, 8 passes 6 in layers, 10 passes 6 in layers, 12 passes
Roller, rubber-tired with tractor, 30-dbhp	3000	sq yd	5 mph, 5 passes
Roller, road, tandem, 5- to 8-ton	1000	sq yd	3 mph, 5 passes
BASE COURSE CONSTRUCTION			
Tractor, 70- to 90-dbhp, with angle-dozer	300	cu yd	Spread material
Grader, motorized	200 450	cu yd sq yd	Spread material Shaping surface
Roller, road, tandem, 5- to 8-ton	300	sq yd	Compacting gravel
Roller, road, tandem, 5- to 8-ton	75	cu yd	Compacting gravel
Roller, rubber-tired, tractor, 30-dbhp	1500	sq yd	Compacting gravel, 10 passes
SURFACE TREATMENTS AND PAVEMENT CONSTRUCTION			
Sweeper, tractor, 30-dbhp	2500	sq yd	Sweeping compact base
Distributor, trailer mounted	2500 1250	sq yd sq yd	0.1 gal per sq yd, 24-ft spray 0.2 gal per sq yd, 24-ft spray
Distributor, truck mounted	(See TM 5-1134)		
Spreader, aggregate, tractor powered	5000	sq yd	Spread cover aggregates
Roller, road tandem, 5- to 8-ton	3000	sq yd	Rolling aggregate, 3 mph, 3 passes
Roller, rubber-tired, tractor, 30-dbhp	3000	sq yd	Rolling aggregate, 5 mph, 5 passes

Table 76. Continued

Equipment	Rate units per hr	Unit	Conditions
SURFACE TREATMENTS AND PAVEMENT CONSTRUCTION–Continued			
Grader, motorized	150	sq yd	Mixed in place, 2-in bituminous material
AGGREGATE PRODUCTION			
Crusher, two-unit, 25 cu yd per hr	15	ton	1-in aggregate, screened
	20	ton	1½-in aggregate, screened
	30	ton	2½-in aggregate, screened
Crusher, (DI-50) tph	18	ton	1-in aggregate, screened
	30	ton	1½-in aggregate, screened
	43	ton	2-in aggregate, screened
Crusher, 225 tph	110	ton	¼-in aggregate, screened, washed
	220	ton	1¼-in aggregate, screened, washed
Crusher 15 tph, Airborne	15	ton	1-in aggregate, crushed
	25	ton	1½-in aggregate, crushed
	38	ton	2-in aggregate, crushed
Compressor, 210 cfm	210	cfm	At sea level
	180	cfm	5000 ft. above sea level
Compressor, 315 cfm	315	cfm	At sea level
	265	cfm	5000 ft. above sea level
Compressor, 600 cfm	600	cfm	At sea level
	510	cfm	5000 ft. above sea level
Drill, rock, 35-lb class	20	lin ft	1¾-in hole, max depth 8 ft. Requires 40 to 60 cfm of air
Drill, rock, 45-lb class	30	lin ft	1¾-in hole, max depth 12 ft. Requires 70 to 90 cfm of air
Scoop loader, wheel 2 cu yd	200	cu yd	Truck loading

*dbhp = drawbar horsepower

Table 77. Approximate Composition of Cutback Asphalts

Type and grade of cutback	Grade of asphalt cement (penetration)	Solvent	% of solvent by volume	% of asphalt cement by volume
SC-3	200 - 225	Diesel oil	22	78
SC-2			30	70
SC-1			38	62
SC-0			50	50
MC-3	120 - 150	Kerosene	22	78
MC-2			27	73
MC-1			35	65
MC-0			45	55
RC-3	85 - 100	Gasoline	16 - 19	81 - 84
RC-2			22 - 25	75 - 78
RC-1			27 - 32	68 - 75
RC-0			37 - 42	58 - 63

67. ROAD CONSTRUCTION IN THE ARCTIC

a. **Nonpermafrost Areas.** Construction design and procedures are generally the same for nonpermafrost for northern areas or for any temperate climate. Allowances are made for the conditions of winter frost; in the arctic and subarctic regions, the depth of frost penetration is greater than in temperate zones. (See TM 5-349).

b. **Permafrost Areas.** In permafrost areas, site selection is the most important of all construction operations. Construction design depends on the surface and subsurface conditions at the selected site. Prime consideration is given to subgrade soil, ground water, surface ice fields, snow, and surface drainage. If at all possible, locate roads on soil composed of coarse-grained, non-frost-active materials, e.g., high-bench gravel terraces. Ground with pores filled by ice or water should be avoided. (See TM 5-349.)

c. **Bridging.** The construction of bridge foundations in permafrost areas is about the same as for other large structures. For detailed information on road and bridge construction in the arctic. (See TM 5-349.)

Section II. Army Airfields and Heliports

68. STANDARDS OF CONSTRUCTION

Army airfields and heliports are divided into three general classes in relation to construction standards; pioneer, hasty, and deliberate.

a. **Pioneer.** Lowest standard of construction, yet maintaining favorable operating conditions. Safety factors at minimum. Runway of soil or sod surface.

b. Hasty. Substondard but operoble margin of safety Reasanably safe ond efficient except in pralanged inclement weather. Runway depends an soil, weather, time af year, avoilability of surfacing material, and length of time field is used.

c. Deliberate. Safety and efficiency standards observed. Can operate under odverse conditians. Must have gaad subgrade ond well-made flexible ar rigid pavement ta be all-weather operable.

69. ARMY AIRFIELD MARKING

The methods outlined belaw are most commanly used in theaters of aperatians.

a. Pianeer. The usable landing area far a pianeer airfield ar heliport is normolly marked by panels. A "T" panel is ploced at the downwind end of the field. A single panel is placed at the upwind end ta mark the limit af the landing roll. If needed, panels may be placed langitudinally alang the sides of the runway to indicate usable width. Because af the updraft fram helicapter rotar blades, panels must be securely fastened to the ground.

b. Hasty

(1) The usable landing area for hasty Army airfields (or heliports) may be marked by painted "sandwich-baard" markers, 55-gallon drums, or ratian cans spaced appraximately 10 feet fram the edge of the runway and 100 feet langitudinally alang the runway. The markers normally are painted black and white. For taxiways, flat pieces af waad or metal 9 by 12 inches in size are fastened to stakes and placed at intervals af 100 feet and about 5 feet fram surface edges ta serve as markers. A mare permanent type of marker may be made by painting rectangular markers 10 feet long and 2 feet wide parallel ta the centerline every 500 feet along bath edges of the runway. Yellaw paint furnishes the highest visibility for this L-shaped markers having 10-faot legs are placed on the faur carners af the runway.

(2) Where portable landing mats are used an hasty airfields, the centerline af the runway may be painted. The end af the runway is accentuated by a rectangular mark nat less than 20 feet by 60 feet, cainciding with the runway centerline.

70. GENERAL NOMENCLATURE OF ARMY AIRFIELDS

The general layout and namenclature are shawn in figures 146 and 147.

71. ARMY AIRFIELD DESIGN CRITERIA

a. Specificatians af Army Airplanes. These specificatian are listed in table 78.

b. Runway Length. The takeaff ground run far the criticol madel of each Army airplane is given in table 78.

72. ARCTIC CONSTRUCTION OF AIRFIELDS

The information on the canstruction af raads in the arctic is generolly pertinent ta air-

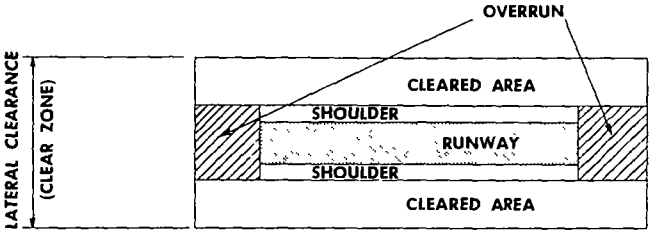


Figure 146. Flightstrip nomenclature.

field construction in arctic areas. Runway design over frost-susceptible soils must take into account frost and permafrost conditions. For detailed information see TM 5-560.

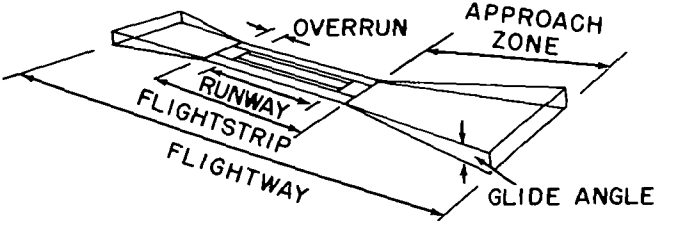


Figure 147. Flightway nomenclature.

73. GENERAL NOMENCLATURE OF ARMY HELIPORTS

See figure 148. Sizes of helicopter pads are given in table 79.

74. ARMY HELIPORT DESIGN CRITERIA

For specifications of Army helicopters, see table 79.

Table 78. Specifications of Army Airplanes*

Type	Gross weight, lbs	Passenger capacity	Cargo, lbs	Overall dimensions			Fuel consumption per hr., gals	Maximum take-off ground run, ft	Take-off distance to clear 50-ft obstacle ft
				Fuselage length	Height	Wingspan			
L-19	2,400	1	191, ea wing	25'9.5"	7'6"	36'0"	55	380	680
L-20A	5,100	4	500, ea wing	30'5"	10'5"	48'0"	138	555	1000
U-1A	8,000	9	NA	41'10"	12'5"	58'0"	141	950	1650
L-23D	7,000	5	NA	31'6"	11'6"	45'4"	204	1280**	2120

* Figures shown are subject to change. Consult most recent airplane publications when they are available.

**Landing ground roll for this airplane is greater than its takeoff ground run; all other planes listed have lesser figures for landing ground roll.

Table 79. Pertinent Specifications of Army Helicopters[1]

Helicoptar type	Army designation	Gross wt, lbs	Fuel consumption (gals per hr)	Passenger capacity	Net cargo, lbs	Sling loads, lbs	Takeoff distance to clear 50-ft obstacle, ft[2]	Size of loading pads	Overall dimensions			
									Length fuselage	Rotor diameter	Height	Tread
Reconnaissance	H-13G	2,350	84	1	210, on skid	NA	250	(Pads must be graded and compacted. Minimum size (rectangular) is:	31'5"	35'2"	8'8"	7'6"
	H-23C	2,500	92	2	178, on	NA	480		28'2"	35'0"	9'10"	7'6"
Utility	H-19D	7,300	270	10	1,000	600	0	Width ½ diameter of rotor blade.	42'2"	53'0"	15'3"	11'0"
Light and Medium Transports	H-21C	13,500	515	20	3,065	250	515	Length: ½ length of helicopter	57'2"	41'0"	15'9"	13'4"
	H-34A	13,300	510	18	4,000	600	0	Circle pad. Size is inscribed inside above rectangle.)	46'9"	56'0"	15'10"	12'0"
	H-37A	31,000	1320	33	6,575	600	250		64'11"	72'0"	22'4"	19'9"

[1]Criteria subject to change; consult most recent aircraft publications, when available.

[2]At sea level, gross weight, hard surface, no wind 59° F, from dead stop.

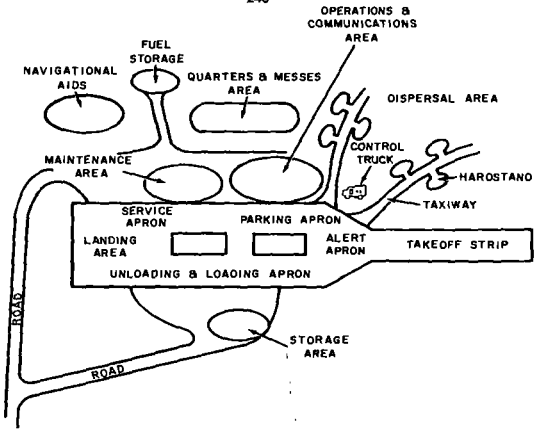


Figure 148. Layout, hasty Army heliport.

CHAPTER 8

MILITARY SANITATION IN COMPANY CAMPS AND BIVOUACS

75. LOCATION OF CAMPSITES

a. **Features for Campsites**

Desirable

(1) Soil – sandy loam or gravel, favorable for waste disposal.

(2) Surface – firm for vehicles, grass covered.

(3) Site – elevated, well drained.

(4) Space – sufficient to avoid crowding of troops and to permit distances between kitchens and latrines: 50 sq. yd. per man, 100 sq yd. per vehicle.

(5) Shade trees for protection from sun and heat

(6) Protected slope or trees as windbreaks in cold weather.

(7) Good road net.

(8) Concealment from air observation.

Undesirable

(1) Dry river bed, ravines, or depressed areas in subject to rainstorms.

(2) Clay, or loose, dusty soil.

(3) Marshy ground, or area near water which may be mosquito infested or subject to mist or heavy dew.

(4) Ground-water level less than 4 feet below surface.

(5) Steep slopes.

(6) Location within one mile of a native village in tropical or subtropical climates.

b. **Security Requirements.** The commander details the bivouac outpost and interior guard. He prescribes the necessary measures for antimechanized defense and for protection against attacks by small groups of the enemy who may succeed in infiltrating the bivouac outpost. The interior guard defends important activities, installations, and materiel, and gives the alarm in event of an attack. Passive measures of defense comprise dispersion, concealment, and cover.

76. LAYOUT

Engineer work at camps and bivouacs includes the following:

a. **Water Supply.** Development of source, purification, storage, organization of water points, and water distribution insofar as that may be directed by higher authority.

b. **Roads, Walkways, Hardstandings, and Traffic Signs.**

c. **Utilities (i.e. Electric).** So for as they are to be provided.

d. **General Construction as Directed.** The erection of tentoge other thon individual shelter, and provision of tent floors, if authorized.

e. **Erection or Supervision of Any Instollotion.** Frections which need speciol skills or special equipment.

f. **Tentoge.** Table 80 gives information on tentage usually authorized to the engineer company level.

Table 80. Tentage

Type	Size	Number ond Length of Pins	Number and Length of Poles
Commond post	20' 7" long x 10' wide x 9' high	20, 16" long 12, 24" long	8, 5' 8" long 2, 9' 0" long
Medium generol purpose	32' 8" long x 16' wide x 10' high	48, 16" long 28, 24" long	1, 17' 0" long 2, 10' 3" long 10, 5' 8" long 4, 6' 2" long
Hexagonol	Each side woll is 6' 7½" long; tent is 8' 6" high	20, 9" long	1, 9' 0" long
Kitchen	18' long x 12' wide x 9' high	31, 16" long 32, 24" long	1, 11' 10" long 1, 5' 11¼" long 2, 12' 3" long 16, 6' 2" long 1, 7' 0" long 5, 9' 0" long
Maintenonce shelter	26' 9½" long x 18' 2" wide x 13' 11 7/16" high	38, 16" long 18, 24" long	
Mountoin (for use only in cold climate)	82" long x 54" wide x 43" high	6, 9" long	12, 15" long
Wall, large	14' long x 14' 6" wide x 11' high	26, 16" long 18, 24" long	1, 14' 2" long 2, 12' 3" long 4, 4' 9" long

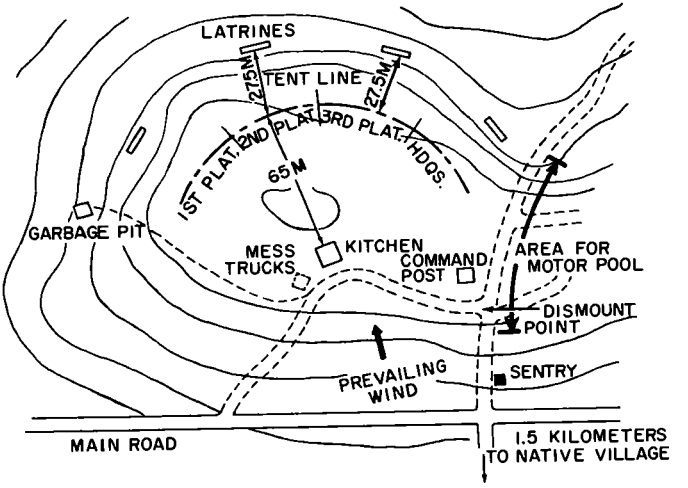


Figure 149. Layaut for a bivauac.

g. **Maintenance and Repair.** This includes aperatians af utilities, for which engineers are respansible, during the period of accupatian of the camp or bivouac.

h. **Layout.** A typical loyaut far o bivauoc is sketched in figure 149. Bivauacs are accupied less than 1 week and have temparory sanitatian facilities.

i. **Security.** Security is abtained by active ond possive measures. Eoch unit designotes rallying points and prepares plons ta fight fires. Important octivities, installatian s, and valuable materiel ore defended by on interior guard. Antitank weapans are emplaced for direct fire agoinst ormared attock. Passive meosures are dispersion, concealment, and cover.

77. LATRINES

a. **General Rules.** Build latrines at leost 100 yards fram unit mess and water source. Do nat dig latrine belaw the water level in the ground, nar locate where it moy drain into o woter saurce. Locate them at least 30 yards from the edge af the unit area. Spray twice weekly with an appraved insecticide. Close them when refuse is within 1 foat of the surfoce, ar when abondoned.

b. Types of Latrines.

(1) The types are straddle trench, deep-pit, mound, bored hole, and pail latrines. Figures 150 and 151 give illustrations of two of these latrines.

(2) Urine disposal facilities should be provided for at least 5 percent of the command. Figure 151 depicts this arrangement.

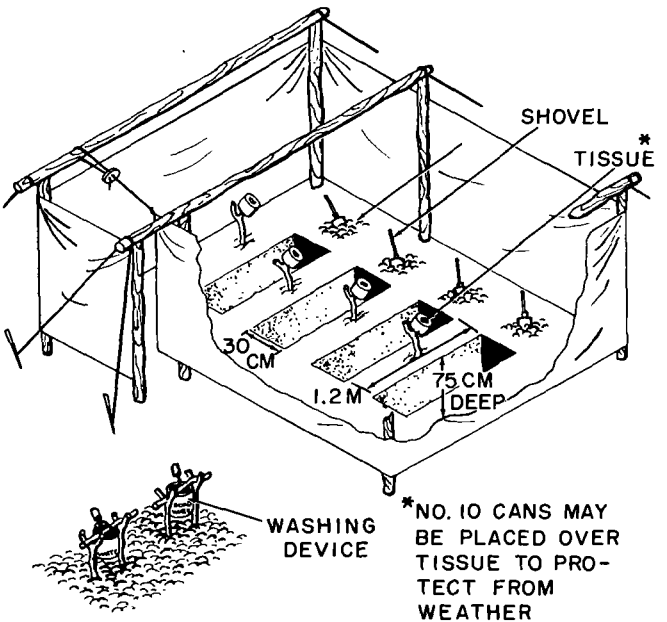


Figure 150 – Straddle trench latrines for 100 men, with handwashing device.

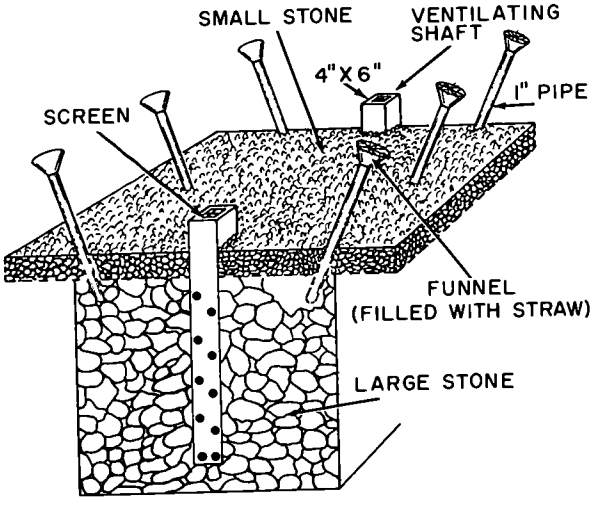


Figure 151 – Pipe urinal arrangement.

78. KITCHEN SANITATION

a. Garbage. A pit 4 feet x 4 feet x 4 feet is suitable as a garbage disposal for 1 day for 100 men. After being filled, the pit is covered with o foot of compacted earth. If buriol is impracticoble, use incinerators.

b. Rubbish. This cotegary comprises emptied contoiners, woste paper, wood, metol, glass, and so forth. Rubbish is bath combustible and noncombustible. In camps and bivauocs, it is buried along with the gorbage.

79. BATHING FACILITIES

a. Handwashing Devices. These facilities should be set up near latrines and kitchens. Figure 152 shows grophically how water cons moy be arranged.

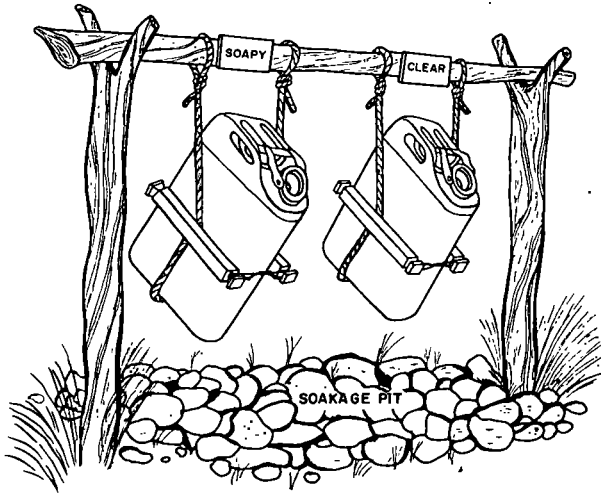


Figure 152 – Handwashing device, using 5-gallon water cans.

b. **Shower Facilities.** Showers should be provided whenever possible for personal hygiene and morale. In the field, showers may be set up as pictured in figure 153.

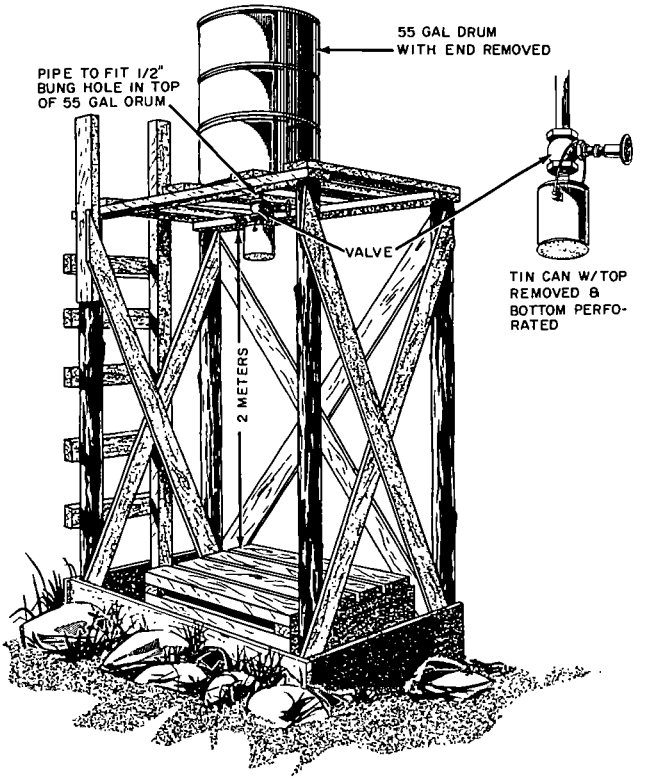


Figure 153. Shower unit, using 55-gallon drum.

CHAPTER 9

MEDICAL INFORMATION

Section I. First Aid

80. THREE BASIC STEPS IN FIRST AID

a. Stop the Bleeding.

(1) For application of direct pressure see figure 154.

(2) If blood is gushing, exert finger pressure on "pressure points" between the heart and the wound. The pressure points are located as follows (fig. 155).

(a) Press just above lower jaw socket (number 1 in fig. 155).

(b) Press upward against jaw bone (number 2 in fig. 155).

(c) Press thumb in front of muscle (number 3 in fig. 155).

(d) Press thumb deep in hollow behind collar bone (number 4 in fig. 155).

(e) Press outward just behind inner border of muscle (number 5 in fig. 155).

(f) Press with both thumbs against bone (number 6 in fig. 155).

Place opened first-aid dressing over the wound. Exert firm pressure on dressing. With severe bleeding, continue hand pressure for 10 to 15 minutes. After 5 to 10 minutes, hand pressure can usually be replaced by pressure of dressing tails wrapped around the injured part.

Figure 154. Application of direct pressure to a wound to control bleeding.

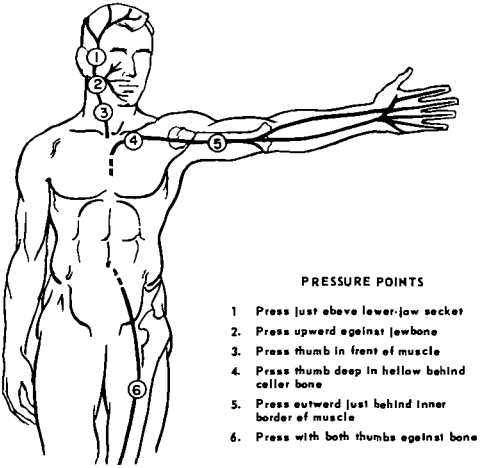

PRESSURE POINTS
1 Press just above lower-jaw socket
2. Press upward against jawbone
3. Press thumb in front of muscle
4. Press thumb deep in hollow behind collar bone
5. Press outward just behind inner border of muscle
6. Press with both thumbs against bone

Figure 155. Pressure points.

(3) Lay patient down with injured part elevated.

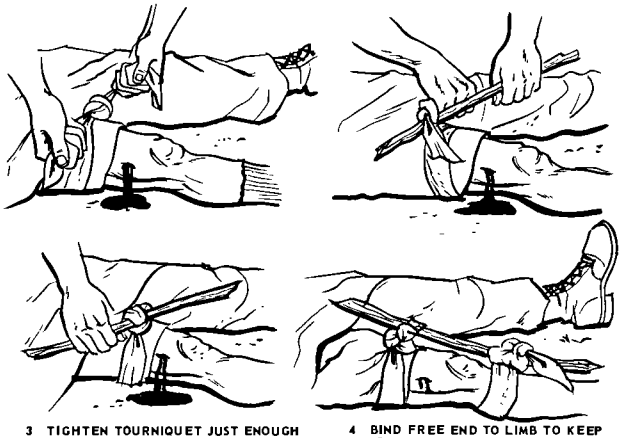
CAUTION: If there is a suspected fracture of an arm or leg, do not raise the injured limb until after it has been properly splinted.

(4) Apply a tourniquet (fig. 156). This will not stop all bleeding immediately. Veins continue to bleed until the limb has been drained of blood already in it. A tourniquet may be applied only when one is sure extremity might be lost. Leave the tourniquet exposed so that it is readily seen. If possible, mark the casualty with a "T" on his forehead (blood may be used) and indicate the time when the tourniquet was applied. (Skin-marking pencils are in Emergency Medical Treatment Unit – Phase I.) Only competent medical personnel should remove a tourniquet.

b. **Protect the Wound.** See figure 157 for protection of a wound.

1 MAKE A LOOP AROUND THE LIMB

2 PASS A STICK, SCABBARD OR BAYONET UNDER THE LOOP



3 TIGHTEN TOURNIQUET JUST ENOUGH TO STOP BLEEDING

4 BIND FREE END TO LIMB TO KEEP TOURNIQUET FROM UNWINDING AND ADD A TIME TAG TO SHOW WHEN TOURNIQUET WAS APPLIED

ONLY A MEDIC OFFICER SHOULD REMOVE OR LOOSEN A TOURNIQUET. REPEATED LOOSENING BY INEXPERIENCED PERSONNEL IS EXTREMELY DANGEROUS.

Figure 156. Apply a tourniquet this way.

c. **Treat for Shock.** See figure 158 for information and illustration.

81. FIRST AID TREATMENT

a. **Treatment.**

(1) Chest wounds. See figure 159 for care of chest wounds.

(2) Belly wounds. See figure 160 for procedure in treatment of these wounds.

(3) Jaw wounds. Figure 161 illustrates the care of jaw wounds.

(4) Head wounds. The care of head wounds is covered in figure 162.

(5) Shock. (See para. 80c above).

(6) Burns.

(a) First degree: reddened skin, no blister. Second degree: skin is blistered. Third degree: skin is destroyed or charred.

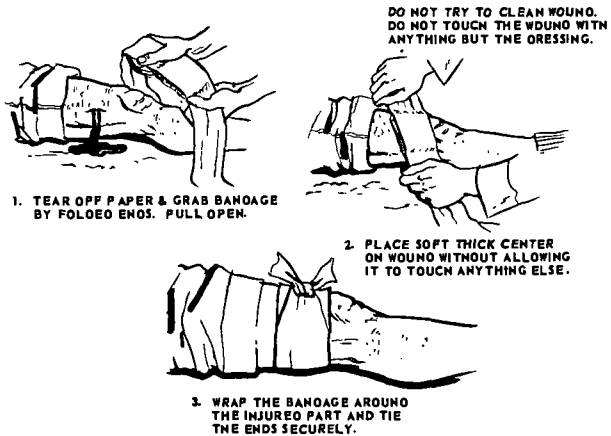

DO NOT TRY TO CLEAN WOUND.
DO NOT TOUCH THE WDUND WITH
ANYTHING BUT THE DRESSING.
1. TEAR OFF PAPER & GRAB BANDAGE
BY FOLDED ENDS. PULL OPEN.
2. PLACE SOFT THICK CENTER
ON WOUND WITHOUT ALLOWING
IT TO TOUCH ANYTHING ELSE.
3. WRAP THE BANDAGE AROUND
THE INJURED PART AND TIE
THE ENDS SECURELY.

Figure 157. Protect the wound.

(b) Carefully remove, or cut clothing away; do not remove cloth that sticks to skin; do not try to clean burn, do not apply ointment to second degree burns. Touch only with sterile dressing.

(c) Following instructions in paragraph 80c for shock, but do not give warm stimulants, give small amounts of cool water with salt, or salt and soda.

(7) Fracture. Tenderness, pain movement, inability to move deformity, swelling and discoloration. Closed fracture has break in bone without break in skin; open fracture has break in skin.

(8) Heat exhaustion.

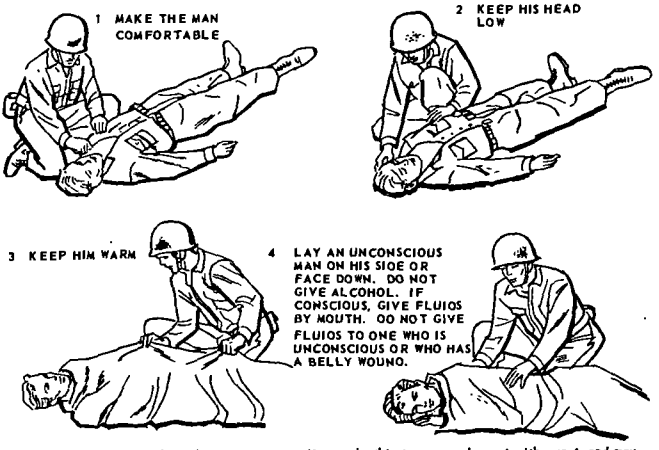
(a) Dizziness and faintness, paleness, moist cool skin.

(b) Lay casualty down in shade, loosen clothing, and give cool salt water if he is conscious.

(9) Heat cramps.

(a) Muscle cramps, especially of intestines, abdomen, arms, or legs. Frequently vomits and is weak.

(b) Give large amounts of salt water as in heat exhaustion.


1 MAKE THE MAN COMFORTABLE
2 KEEP HIS HEAD LOW
3 KEEP HIM WARM
4 LAY AN UNCONSCIOUS MAN ON HIS SIDE OR FACE DOWN. DO NOT GIVE ALCOHOL. IF CONSCIOUS, GIVE FLUIDS BY MOUTH. DO NOT GIVE FLUIDS TO ONE WHO IS UNCONSCIOUS OR WHO HAS A BELLY WOUND.

The victim may tremble and appear nervous. He may be thirsty, very pale, wet with sweat, and may pass out. Shock may not appear until after a lapse of time. Treat the wounded man before shock occurs. Obtain medical aid as soon as possible.

Figure 158. Prevent shock.

(10) Heatstroke.

(a) High body temperature, unconsciousness, stoppage of sweating; hot, dry skin, bright pink color, may be delirious.

(b) Lower body temperature rapidly by immersing in cold water. If no water for bath, place him in shade, remove clothes, and pour water over him. Fan him. Get medical aid. When he regains consciousness, give him cool salt water to drink.

(11) Sunstroke.

(a) Flushed face, dry skin, strong rapid pulse, spots before eyes, headache, high temperature.

(b) Remove from sun and take off clothes. Elevate head and shoulders. Apply cool compresses or bathe casualty in cool water. Give him cool salt water to drink.

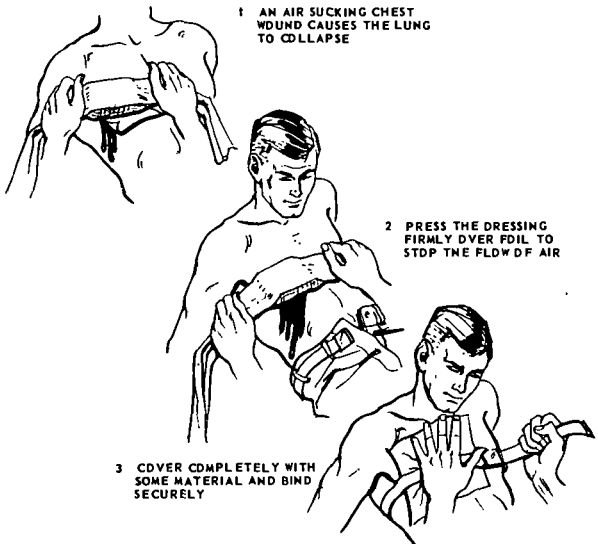

1 AN AIR SUCKING CHEST WOUND CAUSES THE LUNG TO COLLAPSE
2 PRESS THE DRESSING FIRMLY OVER FOIL TO STOP THE FLOW OF AIR
3 COVER COMPLETELY WITH SOME MATERIAL AND BIND SECURELY
MAKE AIRTIGHT AT ONCE. INSTRUCT CASUALTY TO EXHALE AND HOLD BREATH WHILE SEALING WOUND.

Figure 159. Sealing a sucking wound of the chest.

(12) Trench foot. Avoid standing in water, snow or mud, whenever possible, exercise your feet, massage your feet at least once daily, keep socks clean and dry.

(13) Frostbite.

(a) Part of body gets grey or white, and loses feeling. Usually no pain.

(b) Remove clothes at part affected. Place affected part next to body, or warm it gradually at temperature no greater than 98.6 degrees F. Do not

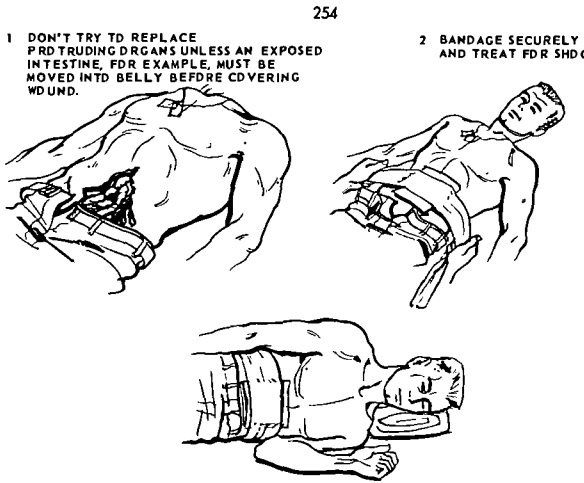

1 DON'T TRY TO REPLACE PROTRUDING ORGANS UNLESS AN EXPOSED INTESTINE, FOR EXAMPLE, MUST BE MOVED INTO BELLY BEFORE COVERING WOUND.
2 BANDAGE SECURELY AND TREAT FOR SHOCK
3 DO NOT GIVE FOOD OR WATER BY MOUTH MOISTEN LIPS

Figure 160. Belly wounds.

use walking, massage, exposure to open fire, cold water soaks, or rubbing with snow. Wrap man in blankets and give warm drinks. After thawing, wrap part loosely in dry, sterile dressing. Do not apply ointment or vaseline gauze. Do not open blisters. Treat as litter patient. Get medical aid.

(14) Drowning. Perform artificial respiration promptly (par. 81b below). Speed is essential.

(15) Snakebite

(a) Within practical limits achieve immediate, absolute immobilization of the affected part in a position below the level of the heart.

(b) Place an improvised, lightly constricting band (tourniquet) two to four inches closer to the heart than the site of the bite and reapply the constricting band ahead of the swelling if it progresses up the arm or leg.

The constricting bond should be placed tightly enough to halt the flow of blood in the superficial blood vessels, but not tightly enough to stop the pulse (arterial flow).

(c) In case the bitten person stops breathing, prolonged mouth-to-mouth or mouth-to-nose artificial resuscitation, as appropriate, should be employed.

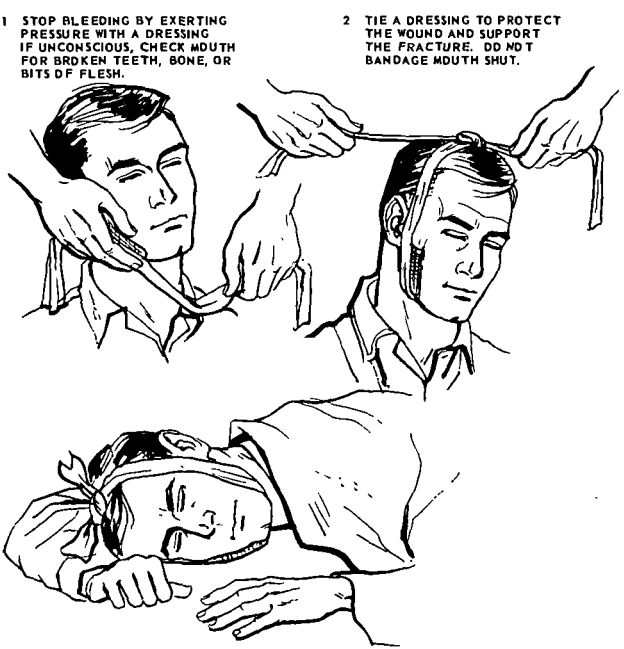

1 STOP BLEEDING BY EXERTING PRESSURE WITH A DRESSING IF UNCONSCIOUS, CHECK MOUTH FOR BROKEN TEETH, BONE, OR BITS OF FLESH.
2 TIE A DRESSING TO PROTECT THE WOUND AND SUPPORT THE FRACTURE. DO NOT BANDAGE MOUTH SHUT.
3 KEEP THE FACE DOWN AND TREAT FOR SHOCK.

Figure 161. Jaw wounds.

Figure 162. Head wounds.

(d) Assistance from the nearest medical source or transportation of the patient to a treatment facility should be accomplished as soon as possible.

(16) Insect bites. Treat same as snakebites.

(17) Poisan plants.

(a) Redness and intense itching; small blisters.

(b) Learn to recognize poisan ivy, poisan oak, and poison sumac (fig. 163). Wash affected parts with water and strang soap before rash appears. Get medical attention.

(18) Cuts and scratches. Protect breaks in skin against infection. Do not touch with hands or clothes. Keep cuts clean. Apply dressing.

(19) Foreign body in eye. See figure 164 for procedure to remove foreign body from eye.

(20) Foreign body in ear, nose or throat.

(a) Never probe in the ear. An insect in the ear may be removed by attracting it with a flashlight held to the ear. If this fails, drown insect by pouring water into ear If the particle is the type which does not swell when wet, it may be flushed with water

(b) Probing into nose generally jams a foreign body tighter. It can damage nasal passages. Gently blow nose to remove foreign body. If this fails, get medical aid.

(c) Coughing will frequently dislodge foreign object from the throat. If not, try to reach it with fingers, but be careful not to push it down throat If all of above methods fail, get medical aid.

(21) Foot trouble. Prevention is best first aid for feet Keep them clean. Dry thoroughly between toes. Use issue foot powder twice daily Change socks daily.

(a) If you acquire "athlete's foot," get medical aid.

(b) Do not cut a corn or callus. Get medical aid.

(c) Keep toenails clean and short To avoid ingrown effects cut toenails straight across; do not round them.

(d) Do not wear socks with holes, with poorly darned spots, or ill fitting.

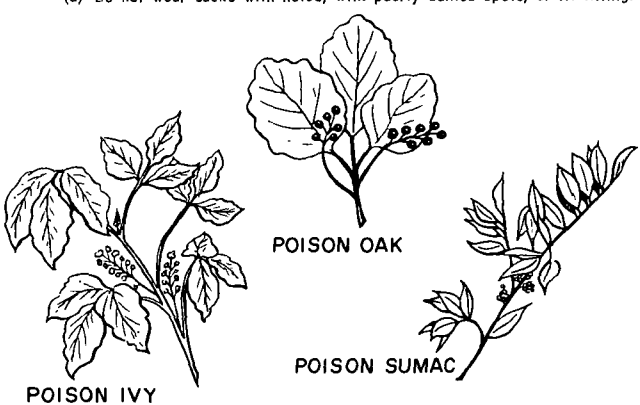


Figure 163. Poison plants.

(e) Break in shoes before wearing them on march.

(22) Unconsciousness.

(a) The cause of unconsciousness may be impossible to learn; it may have been bleeding, heat-stroke, or head injuries. Give casualty first aid which this manual explains in paragraphs under bleeding, head wounds, and effect of bleeding above. Keep casualty lying down if not sure of cause of unconsciousness. Do not move unless necessary, then move gently. If he is cold, see that he gets warm. Do not pour liquids into mouth. Remove false teeth, chewing gum, or other objects from mouth which might cause choking. Take off his equipment. Loosen clothing. Get medical aid.

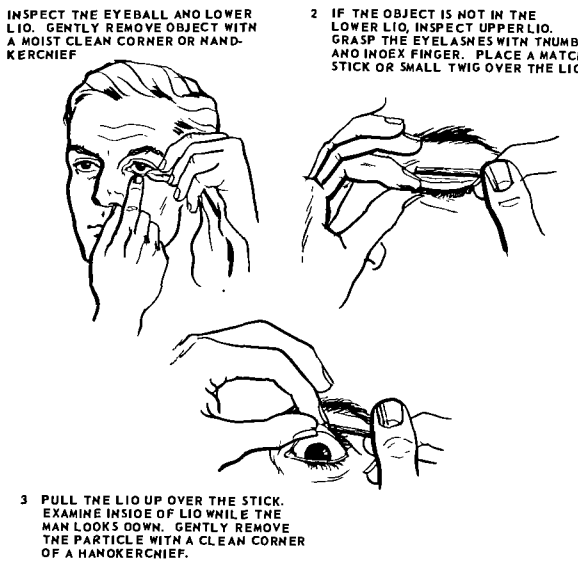

1 INSPECT THE EYEBALL AND LOWER LID. GENTLY REMOVE OBJECT WITH A MOIST CLEAN CORNER OR HANDKERCHIEF
2 IF THE OBJECT IS NOT IN THE LOWER LID, INSPECT UPPER LID. GRASP THE EYELASHES WITH THUMB AND INDEX FINGER. PLACE A MATCH STICK OR SMALL TWIG OVER THE LID
3 PULL THE LID UP OVER THE STICK. EXAMINE INSIDE OF LID WHILE THE MAN LOOKS DOWN. GENTLY REMOVE THE PARTICLE WITH A CLEAN CORNER OF A HANDKERCHIEF.

Figure 164. Removing an object from the eye.

(b) If he has merely fainted, casualty will regain consciousness in few minutes. Keep him quiet. Loosen clothing. Apply wet, cool cloth to face If he shows indications of fainting while sitting up, lower his head between his knees. Do not let him fall. If he faints while sitting up, lay him down gently.

(23) Electric shock.

(a) If he is in contact with electric current, turn it off if switch is nearby. If not, use dry wood pole, dry clothing, dry rope, or some other dry material to remove casualty from contact with current (fig. 165). Do not touch casualty with bare hands.

(b) Electric shock stops breathing; start artificial respiration immediately after freeing casualty from wire.

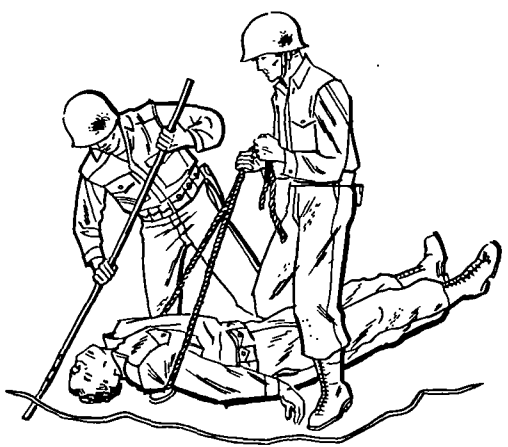


Figure 165. Electric shock.

(24) Carbon monoxide poisoning.

(a) The main source of this gas is auto exhaust fumes, but it can also come from open fires, stoves, and lanterns. Charcoal fires give off carbon monoxide. This gas is odorless. Keep shelters well ventilated.

(b) There is no excuse for carbon monoxide poisoning. It comes from carelessness. Prevent it! Symptoms are dizziness, weakness, headache, vomiting, then unconsciousness. Skin and lips are often bright red. Get casualty into fresh air and start artificial respiration immediately. Keep him quiet.

b. **Resuscitation.** The preferred method of artificial respiration is the mouth-to-mouth method, unless the casualty is in a contaminated atmosphere, at which time the modified Silvester method is used (FM 21-11). The mouth-to-mouth (thumb-jaw lift) is described here. See figures 166 and 167.

c. **First Aid for CBR Casualties.** See table 81 for these first aid measures.

d. **First Aid for Smokes and Incendiaries.**

(1) Imbedded white phosphorus. Remove all particles of phosphorus. Put out burning pieces on the skin with water, then remove. Do not use greases or oils because phosphorus poisoning results. Get medical treatment at the earliest.

(2) Other smokes. Personnel must mask when exposed in confined spaces, when in a downwind area from release point, or during long exposure. Enemy smokes should be considered dangerous until otherwise proven.

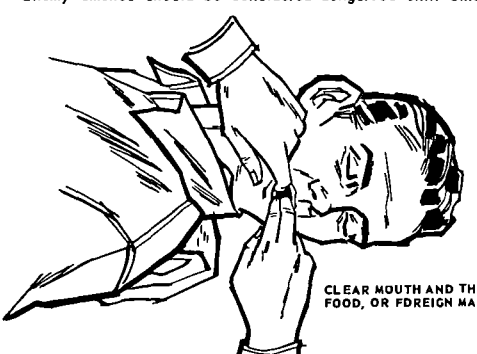


Figure 166. Mouth to mouth (thumb-jaw-lift) method.

PINCH NOSTRILS, OPEN YOUR MOUTH WIDE, AND BLOW UNTIL CHEST RISES. LISTEN AND LOOK FOR SIGNS OF THROAT OBSTRUCTION OR CLOGGED AIR PASSAGE. REPEAT 10 TO 20 TIMES A MINUTE.

Figure 167. Procedure of mouth-to-mouth method.

(3) Incendiaries. White phosphorus, thermite, magnesium, combustible oils, and napalm are the principal incendiaries. Remove particles of thermite from skin. Then use the same first aid treatment as for other burns, including burns from flamethrowers, incendiary bombs, or napalm. Magnesium particles on skin must be removed by trained personnel using local anesthesia. Get medical treatment immediately.

Section II. Chemical Agents

82. RADIOLOGICAL DECONTAMINATION

a. **Tables 81 and 82 present this information.**

b. **Evaluation of Fallout Hazard.**

(1) Prediction. The radiological fallout predictor (DA CTA 3-30) enables small-unit commanders to make an immediate estimate of the location of a potential fallout hazard without waiting for the receipt of a detailed fallout

Table 81. Continued

WHEN	DO THIS	THEN IF --	DO THIS	
AN ATTACK hits your position-- for example	--if tactical situation permits.	Your buddy hos great difficulty getting his breath or etops breathing--	Some as above BUT ALSO give him ARTIFICIAL RESPIRATION. CONTINUE MISSION	NERVE GAS
	4 Give the ALARM.	You feel immediate severe poin in eyes or on skin--	Use BAL eye ointment and decontominate skin CONTINUE MISSION.	
You ore hit by ENEMY BOMBS, SHELLS, or ROCKETS--	5 DECONTAMINATE	You hove drops or sploshes in eyes or on skin but feel NO immediate severe poin--	Flush eyes with water only and decontominate skin by procedure below. CONTINUE MISSION.	
	--remove wet spots from SKIN and clothes.	You hove wet spots on clothes--	Cut awoy spots and rub skin with protective ointment. CONTINUE MISSION	BLISTER GAS
SPRAY from an AIRPLANE falls on you--	6 CONTINUE MISSION.	You begin breathing rapidly or gasping for air--	Move to fresh air if poseible. Inhale amyl nitrite.	BLOOD GAS
A low CLOUD drifts over you--	REMAIN MASKED UNTIL AREA HAS BEEN DECLARED SAFE	You cough or choke. Your chest becomes tight--	Loosen clothing. CONTINUE MISSION If shortnese of breath occure, keep worm and quiet.	CHOKING GAS
		There is no apparent effect on anyone--	CONTINUE MISSION. Observe diseose prevention rules, keep wounds and cuts clean; eat and drink only approved food and water	BW AGENT
		If later (1 to 10 days) you or your buddies get sick--	Get medical aid and report sickness.	

Table 81. Nuclear Attack

INDIVIDUAL ACTION TO PROTECT AGAINST A NUCLEAR BURST			EFFECTS OF A NUCLEAR BURST		
BEFORE BURST	If ALERT is sounded, follow unit SOP. If warned before explosion, pick strongest shelter you can find in a hurry. Underground shelters, basements, deep foxholes, and tanks *give good protection.*		BLAST	SUDDEN SHOCK	Shock pressure from burst is not enough to kill. Flying objects cause almost all injuries. Keep down, close to shelter.
DURING AND AFTER BURST	1 TAKE COVER	If you see BRILLIANT LIGHT brighter than sunlight, DIVE FAST to put something (dirt, tree, wall) between you and explosion. FALL FLAT on ground, face down, if you cannot reach shelter in 1 step. CLOSE EYES. Keep head covered. Protect FACE and HANDS. *Stay until blast effect is over or until heavy material has stopped falling.*	HEAT	1 FLASH HEAT	Bare skin can be burned at great distance from explosion. Your clothes or any other *material which will cast a shadow gives* protection. Keep minimum amount of skin area exposed.
				2 FIRES	Flash heat starts forest and brush fires. Fuel and short-circuits start others. Fight these fires in the normal manner.
	2 STAY CALM	Be ready for orders and instructions. Help *your leaders to re-form your unit. Your life* and your unit depend on your doing the right thing at the right time.	NUCLEAR RADIATION	1 PROMPT RADIATION	Most radiation occurs in the first 2 seconds of explosion. By the time objects have stopped falling there is no danger from prompt radiation. In most cases, if you are not wounded or burned, you need not worry about prompt radiation.
	3 CONTINUE MISSION	The nuclear burst is only one part of the enemy's plan. Be ready for more to come. Expect an enemy attack after an explosion near your position. Be prepared to attack *following an explosion on enemy positions.*		2 FALLOUT	From an air burst, it is not dangerous. If fallout follows another kind of burst, you will be told what to do.

	BIOLOGICAL OR CHEMICAL ATTACK			
WHEN	DO THIS	THEN IF --	-- DO THIS	
A TOXIC AGENT is suspected--	1 STOP BREATHING	Your nose starts running suddenly-- Your chest feels tight-- Your eyesight gets dim-- Breathing become difficult--	Give yourself 1 atropine shot and fasten used tube on shirt or jacket pocket. CONTINUE MISSION	
The ALARM is sounded--	2 MASK. 3 Take COVER	Your buddy has difficulty breathing-- slobbers, sweats, or vomits-- twitches, jerks, or staggers--	Mask your buddy and give him his atropine shot if he has not taken it. Call medic. CONTINUE MISSION.	NERVE GAS

Table 82. Radialagical Decantaminatian

Item	Methad	Equipment ar decantaminant	Remarks
Clathing	Vacuum clean	Vacuum cleaning machinery.	Dispase af cantamination removed by machine filter.
	Wash.	Laundry.	Dispase af water used for washing and rinsing.
Equipment	Depends on nature af surface.	----------	See tables LVI and LVII (FM 3-8).
Buildings	Abrasian, caustics.	----------	See tables LVI and LVII (FM 3-8).
Terroin	Decay.	Nane.	Wait for natural decay.
Water	Water treatment.	Filters, stills, and purifiers (engineer equipment).	Must be pronaunced safe by medical afficer ar water specialist.
Faad exposed	Generally, nane, dispase af, isalate, or shield.	Digging equipment.	Nat safe ar practicable ta attempt ta remave radiological cantaminatian fram exposed ar apened faad.
Faad covered	Scrub ar wash.	Brushes ar hase.	Must nat be unwrapped ar peeled until lawering af cantamination level is adequate and pranaunced safe by medical afficer.
Personnel	Bathing, scrubbing, shawering, washing.	Brushes, hase, shawers, saap.	Bathing and scrubbing must be cantinued until cantamination is lawered ta a safe level.

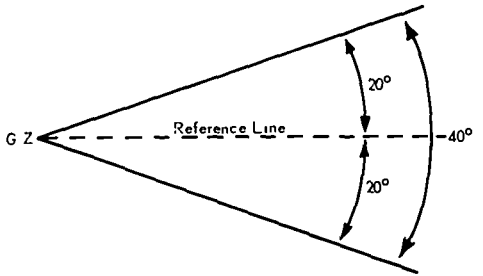
prediction report from the Chemical, Bialagical, Radialagical Center (CBRC) at divisian level and Chemical, Bialagical, Radialagical Element (CBRE) at carps and army level. If a fallaut predictar is nat available, it can be praduced locally by the following pracedure.

(a) Step 1. On a piece af pliable, transparent material draw a thin, dotted line (a reference line) ta a length af 20 miles (using apprapriate map scale) from a paint selected ta represent graund zera.

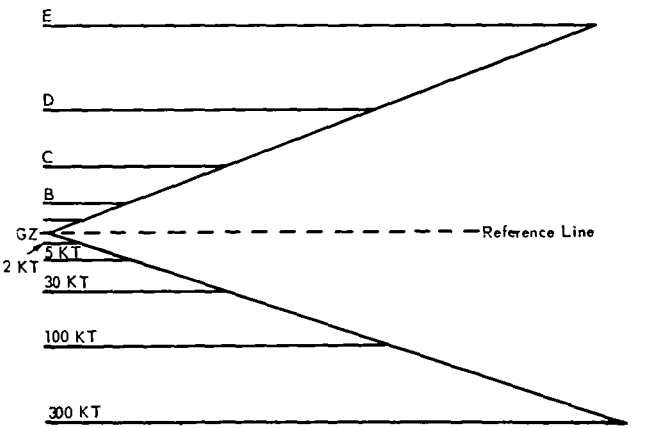
GZ Reference line

\+ ----------

(b) Step 2. Draw two radial lines from ground zero at angles of 20° to the left and right of *the reference* line.



(c) Step 3. On the side of ground zero opposite *the reference* line, draw a series of concentric semicircles (using the appropriate map scale) having radii of 0.75 mile, 1.1 miles, 2.25 miles, 3.75 miles, and 5.8 miles, corresponding to cloud radii from *nuclear bursts* of yields of 2KT, 5KT, 30KT, 100KT, and 300KT, respectively.



(d) Step 4. From the ends of the semicircles, draw straight lines parallel to the datted reference lines ta the sides of the twa radial lines. Lobel these lines (starting with the line clasest ta GZ and moving up fram GZ) A, B, C, D, ond E. Moving dawn fram GZ, lobel the lines 2KT, 5KT, 30KT, 100KT, and 300KT, respectively.

(e) Step 5. Using the oppropriate map scale, graduate the datted reference line and the two radial lines in miles.

(f) To use this field-constructed follout predictar, place a pratroctor aver an ossumed GZ on the map, and drow o line representing the effective wind direction far the yield group af interest. Ploce GZ of the predictar over on the map and rotate it about ground zero until the dotted reference line of the predictor canincides with the effective wind direction. Use figure 168 to determine the dawnwind distonce of the zane of immediate operatianal concern, and drow an orc at this distance between the appropriate yield graup cantour lines. Then draw an arc ot twice this distance ta obtain the dawnwind distonce for the zone of moderate risk. The dots far effective wind speed and direction ore received fram CBRC/CBRE.

(2) Monitaring. The radiacmeter (IM-108/PD) is the standard Army survey meter used for radiological manitoring. Graund surveys con be conducted by personnel on foot ar in vehicles, but these surveys will be conducted in armored vehicles, whenever passible.

(a) Primary method. Take readings with the radiacmeter held 3 feet obove the cupolo of tank or armared personnel corrier (APC). Record the dose rates together with times and locations on DA farm 1971-R (fig. 169) Obtain the vehicle shielding correction foctor by use of the follawing farmula:

$$\text{VSCR} = \frac{\text{Dose rate with instrument autside vehicle.}}{\text{Dose rote with instrument inside vehicle.}}$$

When a direct determination cannot be mode far this correction, the follawing table is appropriate.

Type of vehicle	Carrectian factor	
	Internal	External
Tank, M41 or M48	100	1.5
APC, M59, M84, M113, ar M114	20	1.5

At least three sets af graund and vehicle readings should be taken ot equal intervals thraughaut the contaminoted areo.

(b) Alternate method. This method is for use when the primary method cannat be used. Readings ore taken fram inside the vehicle with hotches closed. The farmula in (a), obove, is used ta get the vehicle carrection foctar.

(c) Survey routes. Survey parties should follow predetermined routes and report dose rates, location, and times of readings, as directed by CBRC or CBRE, or control party. Include well-defined terrain features, points of operational interest, measured distances along the route, and prescribed dose rates.

NOTE: Further information may be found in TC 101-1, w/C2.

83. PERSISTENT WAR GAS DECONTAMINATION

See table 83 for this information.

84. BIOLOGICAL DECONTAMINATION

See table 84 for instruction on biological decontamination.

85. TRANSPORTATION OF SICK AND WOUNDED

a. General. Seriously injured persons must be moved with care and skill; otherwise their injuries may be made more serious. It may even result in the casualty's death. Do not move him unless absolutely necessary; await a litter or ambulance. But there will be times when you may have to move the injured, so you should learn the different ways of doing it. Also, before you move a casualty, give him first aid. If he has a broken bone, splint it before moving him.

b. Improvised Litters.

(1) Pole and blanket litter. A blanket, shelter half, tarpaulin, or other material may be used for the litter bed. Make the poles from branches, tent poles, rifles, skis, and so forth (fig. 170).

CAUTION: If rifles are used, make sure they are unloaded.

(2) Blanket roll litter. If no poles can be obtained, roll a blanket, shelter half, or tarpaulin from both sides toward the center. Use the rolls as grips.

c. Carries. Shown in figures 171 and 172 are ways of moving a casualty without a litter. Use the most convenient for you and for the situation. Never carry a casualty who has a broken back or neck.

(1) Fireman's carry. This is the easiest method by which one man can carry another (fig. 171).

(2) Supporting carry. Grasp the wrist of the casualty's uninjured arm and draw his arm around your neck. He can then walk, with you as a crutch. It is useful for foot and ankle injuries (fig. 172).

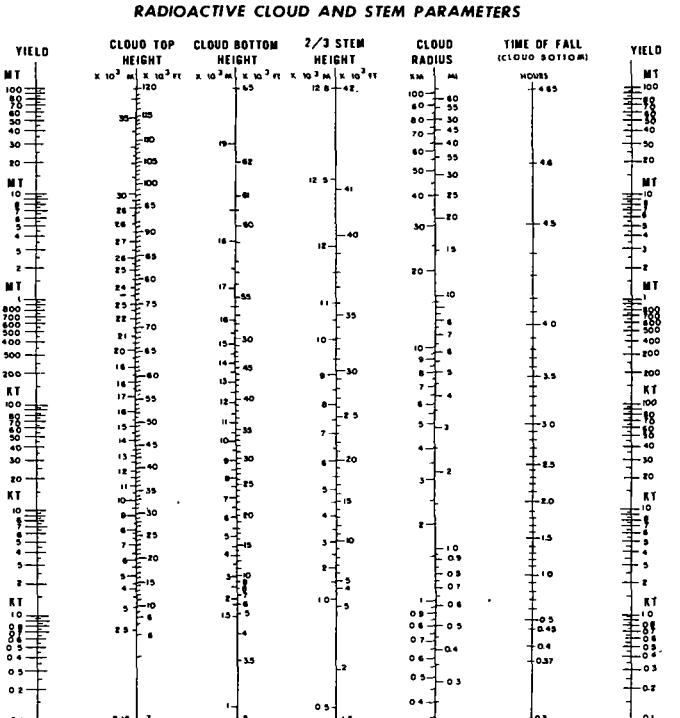


Figure 168. Radioactive cloud and stem parameter.

DATA SHEET FOR RADIOLOGICAL SURVEYS (GROUND) [TC 101-1]

DATE: 21 Nov 58 | PAGE NO. 1 | NO. OF PAGES 1

PARTY: #10 RADC, 1st Div

MAP: Kurlso, 1/50,000, SHEET I

VEHICLE TYPE: Jeep

INSTRUMENT NO.: Set

READING NUMBER	LOCATION	DOSE RATE r/hr	TIME	READING NUMBER	LOCATION	DOSE RATE r/hr	TIME
1	DE	10	0540	15	GA	30	0619
2	040217	10	0542				
3	043225	4	0545				
4	DG	7	0550				
5	042227	15	0553				
6	043231	20	0556				
7	043236	25	0600				
8	044235	30	0602				
9	FH	40	0604				
10	043245	45	0607				
11	040248	40	0609				
12	037246	40	0612				
13	037251	35	0614				
14	037257	40	0616				

REMARKS: None

VEHICLE SHIELDING CORRECTION FACTOR DATA

LOCATION	DOSE RATE - r/hr: INSTRUMENT IN VEHICLE OR PROBE ON VEHICLE	DOSE RATE - r/hr: INSTRUMENT OUTSIDE VEHICLE OR PROBE AWAY FROM VEHICLE	LOCATION	DOSE RATE - r/hr: INSTRUMENT IN VEHICLE OR PROBE ON VEHICLE	DOSE RATE - r/hr: INSTRUMENT OUTSIDE VEHICLE OR PROBE AWAY FROM VEHICLE
DE	10	14			
043225	4	6			
043236	25	35			

MONITOR

TYPED OR PRINTED NAME AND GRADE	SERVICE NUMBER	SIGNATURE
William L. Smith, Pfc	RA00000000	William L. Smith

DA Form 1971-R, 1 Nov 58 EDITION OF 1 MAY 57 IS OBSOLETE.

Figure 169. Completed data sheet (DA form 197-R) showing sample series of a ground survey.

Table 83. Continued

Basic material	Decontaminant (method)		Field expedient
	Primary	Secondary	
Metals (bore)[1]	Water	DANC solution[4] (then clean and oil). Solvents.	Aerate.
Painted surfaces	DANC solution[4]	Slurry. Washing solvents.	Blot off surfaces.[1]
Plaster[1]	Slurry	Aeration	Allow to weather.
Plastics (opaque)[1]	Slurry (apply carefully)	Washing. Weathering.	Allow to weather.
Plastics (transparent)	Hot soapy water	Gasoline or kerosene.	Blot off surfaces.[1]
Rubber (natural and synthetic)	Boiling water[5] (immerse for 2 to 3 hrs).	Slurry	Apply protective ointment.
	Boiling water[5] (immerse for 6 to 8 hrs).	Slurry	Apply protective ointment.
Sand	Bleach	Slurry	Cover with earth. Scrape off 3 to 4 in. of top layer. Allow to weather. Burn.
Undergrowth and tall grass	Slurry.[1] Explosives	Fire exploding of bleach drums.	Allow to weather.
Water	Superchlorination	Dechlorination	NA
Wood	Bleach. Slurry.[1] Boiling water (immerse for ½ to 1 hr).	DANC solution[4]	Burn.

[1]Aerate after treatment.

[2]When liquid contaminant is visible and personnel are nearby, dry mix should be used.

[3]If applicable.

[4]Do not use DANC solution for decontamination of G-series warfare agents.

[5]Length of treatment depends on amount of contamination, thickness of rubber, and future use.

Table 83. Persistent War Gas Decontomination

Bosic materiol	Decontominont (method)		Field expedient
	Primary	Secondary	
Asphalt[1]	Bleach[2]	Slurry	Cover with earth.[3]
Brick or stone[1]	Bleach[2]	Slurry	Cover with earth.[3]
Convas	Hot, 5% woshing sodo (sodium corbonote) oqueous solution (immerse for ½ to 1 hr).	Boiling woter	Aerote.
Cotton ond wool	Boiling water (immerse for ½ to 1 hr; for cottans, water must be made alkoline – 2 oz woshing sodo per 10 gol woter).	Laundering process.	Apply protective ointment. Aerote.
Concrete[1]	Bleach.[2] Slurry	DANC solution[4]	Cover with earth.[3]
Eorth[1]	Bleoch.[2]	Slurry	Cover with uncontominoted eorth. Scrope off 3 to 4 in. of top soil. Allow to weother. Burn.
Glass	DANC solution[4]	Woshing[1]	Blot off surfoces.
Grass ond low vegetation[1].	Bleoch.[2] Slurry	Fire	Cover with eorth. Scrope off 3 to 4 in. of top soil. Allow to weother.
Impermeoble fobrics	Boiling woter (immerse for ½ to 1 hr).	Slurry (keep bleack off of fobric side).	Allow to weother.
Leother	Woter ot 120°F. (immerse for 4 hrs)	Aerotion DANC solution.[4]	Blot off surfoces.

Table 84. Continued

Item	Method	Remarks
	Using decontominoting opporotus for washing with soop ond water.	Suitoble for interior of buildings.
	Weothering	Sun, wind, ond roin usuolly eliminote exterior germs within o few hours.
Terroin:		
All	Weathering	Evacuote contaminated area and ollow sufficient time for weothering.
All	Wetting with woter	Will keep germs on ground.
Porous	Spraying with slurry (20% bleach solution).	Suitoble to limited extent for some types of terroin.
Hard surfoced roods.	Pouring, spraying, or spreading oil.	Will keep germs on ground.
Vegetotion	Burning with flome thrower.	Con be used to burn off oreos ond possogewoys.
Air (inclosed spoces)	Filter oir by meons of protective collector.	Renders oir relotively free from germs.
	Spraying calcium or sodium hypochlorite solution.	Can kill consideroble portion, thaugh not oll, of oirborne germs in inclosed spoces.
	Voporizing triethylene glycol.	Can kill consideroble portion, though not oll, of oirborne germs in inclosed spoces.
Woter[3]	Boiling for 10 min	
	Chlorinotion	Generolly effective for killing most horrnful orgonisms.
	Superchlorination, Corps of Engineers Equipment	For heovy contaminotian Follow with dechlorination.

Toble 84. Biological Decontaminotion

Item	Mathad	Remarks
Cotton clothing	Bailing in water far 15 min.	
	Autaclaving far 15 min. at 123 [a] C.	
	Immersion in 7% blaach solution for 30 min.	Immediate rinse required.
	Loundering	Destrays ar inactivates all but highly resistant spare-farming arganisms.
	Methyl bramide vapors[1] in dalousing bags.	Leave in bag far 12 hrs, then aerate for 2 hrs ta remova vapar.
Fine instruments, mask facepiaces.[2]	Methyl bromida vapors[1] in dalausing bags.	Leave in bag far 12 hrs, then aarate far 2 hrs ta ramove vapar.
Helmets and mass gaar.	Washing with saap and watar and bailing for 15 min.	
	Methyl bramida vapors[1] in dalausing bags.	Leave in bag far 12 hrs, then aarata far 2 hrs ar wash ta remava vapar.
Leather and rubber items.	Methyl bramida vapors[1] in dalausing bags.	Leave in bag far 12 hrs, than aerata far 2 hrs ta remava vapar.
	Scrubbing with soap and hot watar for 20 min.	
Large items	Scrubbing with DANC solutian, ar 7% bleach solution.	Requires water rinsing ar flushing after scrubbing.
Buildings	Fumigatian with farmaldehyda and staam.	1 ml af farmaldehyda salutian per cu. ft. Building is sealad bafare fumigation and thoraughly aerated aftarwards.
	Spraying with formaldahyde, ar glycerin-farmaldehyde.	Suitable for furniture and interior surfaces of buildings.

Table 84. Continued

Item	Method	Remarks
Food[3]	Boiling in water for 10 min.	
	Cooking	Thorough cooking insures effective destruction of microorganisms.
	Immersion or spraying	Packaged food or food which is peeled or pared may be immersed or sprayed.
Personnel (Hands)[4]	Bathing with soap and warm water.	Remove clothing and shower for 20 min.
	Washing with hypochlorite or cresol.	

[1]In five times the quantity used for ordinary delousing. Ethylene oxide is used when methyl bromide is not available.

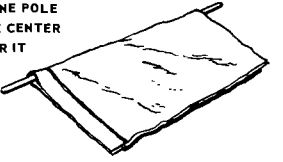
[2]To effectively decontaminate facepieces of protective masks, boil in water, wash in lukewarm soapy water, rinse in clear water, and then dry at room temperature. Masks determined to be infected with mycobacterium tuberculosis or pathogenic spore-forming organisms should be destroyed by burning.

[3]Should not be consumed until pronounced safe by a medical officer.

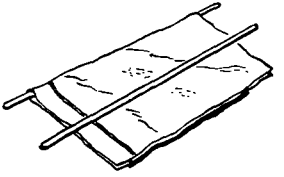
[4]Minor cuts and abrasions should be treated immediately.

[5]When showering, head should be held back to prevent run-off from passing over eyes, nose, and mouth.

1 OPEN A BLANKET, LAY ONE POLE LENGTHWISE ACROSS THE CENTER AND FOLD BLANKET OVER IT



2 PLACE THE SECOND POLE ACROSS THE CENTER OF THE NEW FOLD



3 FOLD THE FREE EDGES OF THE BLANKET OVER THE SECOND POLE

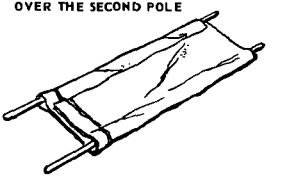


Figure 170. Pole and blanket litter.

Figure 171. Fireman's carry.

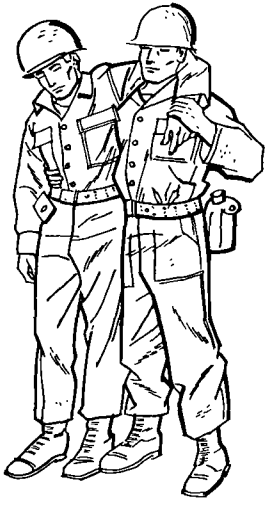


Figure 172. Supporting carry.

CHAPTER 10

RECONNAISSANCE

Section I. Introduction

86. TYPES OF RECONNAISSANCE

a. Route Reconnaissance.

(1) Route reconnoissance is governed by the some fundomentols thot opply to oll reconnoissonce. It is usuolly mode on the ground, but it should be supplemented by oir reconnoissonce when practicoble. Route reconnoissonce is to give informotion to oid in route selection for the movement of troops, equipment, and supplies.

(2) Informotion sought in this type of reconnoissonce includes:

(a) Noture of terroin.

(b) Whot roods exist ond their chorocteristics, including lood-beoring copobilities. (See TM 5-250 for more detoiled informotion).

(c) Obstructions.

(d) Bridges ond other streom crossing meons.

(e) Tunnels.

(3) Route reconnoissonce must consider the mission of the parent unit. Reconnoissonce is mode in considerotion of the weight, width, ond height of the vehicles thot will be used, the classificotion of these vehicles; the opproximote number of eoch closs to be moved per hour; and the opproximote length of time the route will be used.

(4) A route reconnoissonce report should be occurote, concise, ond cleor. The preferred method of preporotion is in simplified mop form (fig. 173) or overloy, using symbols (fig. 174) to show the limiting feotures. A route reconnoissonce report is occomponied by o rood reconnoissonce report ond bridge, tunnel, ferry, and ford reconnoissonce reports os needed. Militory sketches of limiting feotures, local maps, ond photogrophs of significont foctors (terroin, roods, tunnels, bridges, ferries, fords, and so forth) support the route report.

(5) Symbols for use in preparing o route reconnoissonce report are listed below and olso oppeor in figures 173 and 174.

(a) Length (in kilometers) between well marked points may be shown.

(b) Curves having radii of less than 30 meters with these rodii marked in feet or meters.

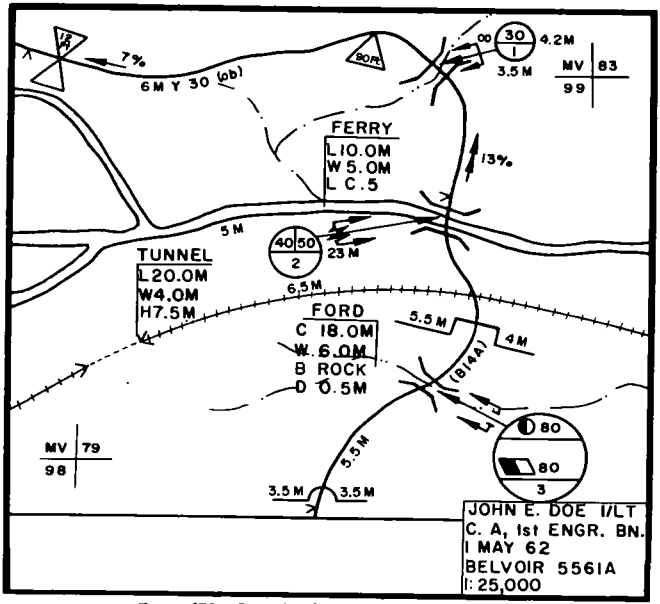


Figure 173. Exomple of route reconnaissance report.

(c) Steep grades, with their moximum gradients in percent, and length of any grode af 7 percent or greater.

(d) Rood width af constrictions, with the widths af the traveled ways in meters; their lengths in kilometers.

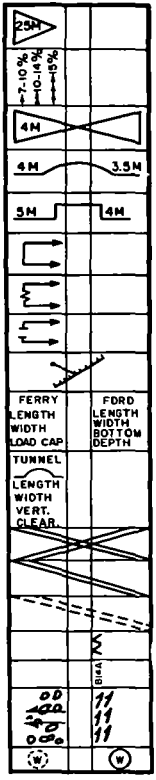
(e) Underposs limitations, with their limiting heights and widths in meters.

(f) Bridge bypasses, classified as easy, difficult, at impossible (c below).

(g) Civil or military raad numbers, or other designations.

(h) Feasibility of driving off roads, including shoulders.

(i) Locations of fords ond ferries, including limiting infarmatian.



(1) Sharp Curve
(radius in feet or meters)

(2) Steep Grade (arrows point uphill) (grade in percent) (length of arrows may show length of grade when scale allows)

(3) Constriction (width in meters)

(4) Arch constriction (width on left & height on right in meters)

(5) Underpass Constriction (width on left & height on right in feet or meters)

(6) Bypass easy

(7) Bypass difficult

(8) Bypass *impossible*

(9) Level crossing

10) Ford (Length, width, bottom, and depth) Ferry (Length, width, load capacity)

(11) Tunnel (Shape, length, width, vertical clearance)

(12) Road Block

(13) Road Block (ready to use but not in position)

(14) Proposed Road Block

(15) Limits of Sector

(16) Civil or Military Route Designation

(17) Cover (woods) (deciduous – left) (evergreen – right) Arrow denotes possibility of driving off the road into deciduous cover.

(18) Possible waterpoint/waterpoint in operation

Figure 174. Overlay symbols.

(6) Route classificatian formula. Symbols for route reconnaissance maps or overlays are shown in figures 173 and 174. Further symbols are as follows:

(a) Types of roads.

1 (X) All-weather -- Any road which, with reasonable maintenance, is passable thraughout the yeor to a volume of traffic never appreciably less than its maximum good weather capacity. This type of road has a waterproof surface and is anly slightly affected by rain, frost, thaw or heat. At no time is it closed to traffic due to weather effects other than snow blockage. The following are examples of this category: Concrete; Bituminous; Brick or Stone.

2 (Y) Limited All-weather -- Any road which, with reasonable maintenance, can be kept open in bad weather to a volume of traffic which is considerably less than its normal good weather capacity. This type of road does not have a waterproof surface and is considerably affected by rain, frost or thaw. The following are examples of this category: Crushed rock ar Waterbound macadam; Gravel ar lightly metaled surface.

3 (Z) Fair weather -- A road which becomes quickly impassable in bad weather and which cannot be kept open by normal maintenance. This type af road is seriously affected by rain, frost or thaw. The following are examples of this type: Natural or stabilized soil, Sand or Clay; Shell, Cinders; Disintegrated granite.

(b) Formulas.

1 20 feet Y 50 describes a route 20 feet wide (minimum), limited all-weather type, and laad classification of class 50.

2 20 feet Y 50 (Ob). "(Ob)" indicates an obstruction along the route.

3 20 feet Y 50 (T). "(T)" represents snow blockage.

4 20 feet Y 50 (W). "(W)" represents flooding.

(c) Causeways, snowsheds, and galleries. Although these structures are not often encountered in a route reconnaissance, when they constitute an obstruction to traffic they should be included in the route reconnaissance repart. Limit the data to clearances and load-carrying capacity. If possible, support the informatian with phatagraphs or a sketch of each structure. Also, include enough descriptive information to permit an evaluation concerning the strengthening or removal af these structures.

1 A causeway is a raised woy across wet or unstable ground.

2 A snowshed is a shelter protecting something from snow, such as a long structure over an exposed part of a road or railroad.

3 A gollery is o sunken or cut passogewoy covered overhead as well os ot the sides. In a combot areo, o gallery may be importont not only because it moy be an obstruction, but because it moy offord additionol protection.

b. *Raad Recannoissance.*

(1) Raad reconnaissance is performed to get infarmation an raad classificotion, primorily in support af selecting a route, and report changes to existing mops for dissemination in the theater af operotions. Its moin concern is with existing rood conditions and nat far maintenance operotians. Its purpose is to find out the quantity ond kind af troffic ond laods thot a raod can accammadate in its present conditian. It moy include estimates of the procticobility of improvement and the amount of engineer effort necessory ta prepare a route far specified troffic ond loods. Obtaining dota far complete rood classificotian should be done by an engineer.

(2) Informotion required·

(a) Local name af rood.

(b) Local rood designotion ond number.

(c) Locatian of rood by map grid reference.

(d) Obstructions, which include, among other items, underposses, fords, lorge tree limbs, croters, projecting buildings, areos subject to inundotion, and so forth.

(e) Bridge locations. (Bridge reconnaissance is outlined in c below.)

(f) Tunnel locatians, together with their lengths, widths, and heights. (Tunnel reconnaissance is described in d below.)

(g) Snowshed locations and estimoted coverage.

(h) Snow gollery locotions, together with their lengths, widths, and heights.

(i) Other requirements are listed in a(5)(a) through (e), ond (j), obove.

(3) Rood classificotion formula. Rood chorocteristics ore expressed by definition ond symbols in the following order: limiting factors, width, construction material, ond, if desired, length.

(a) Limiting factars. The symbol "A" is used if there are no limiting factors. The symbol "B" meons one or more limiting foctors. A question mork in parentheses (?) means an unknown limiting foctor. A V-like symbol on o mop or overlay represents the terminol points of the road sector. (See fig. 173.) Table 85 shows limiting factors, their criterio, ond symbols representing them.

(b) Width. The troveled woy of o rood is expressed in feet or meters followed by o slash, with the width of troveled woy and shoulders combined, as 14/16.

(c) Construction moterials. See toble 86 for these symbols.

(d) Length. This moy be shown, if desired, in porentheses ot the end of o rood classificotion formulo.

(e) Exomples.

1 A 5.0/6.2 mk -- concrete rood, 5.0 meters wide. 6.2 meters, including shoulders; no limiting factors.

2 Bgs 14/16 ft 1 (Ob) -- grovel or lightly metolled, 14 feet wide, 16 feet, including shoulders, steep grodients; rough surfoce; ond obstructions.

3 Bc (f ?) 3.2/4.8 m p (4.3 km) T -- Poving brick or stone. 3.2 meters wide. 4.8 meters, including shoulders; sharp curves, foundation unknown, 4.3 kilometers lang; ond subject to snow blockage.

(4) Meosuring curves.

(a) One methad of measuring short-rodius curves may be dane with o card ta swing an arc (fig. 175). For radii up ta 75 meters and lacated on level graund, this method is practical.

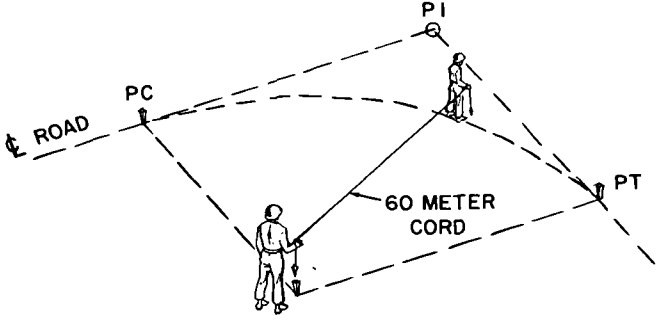


Figure 175. A curve stoked by using o card.

(b) Another method for determining the radius of o curve is bosed an the formulo:

$R = C^2/8m + m/2$ (fig. 176)

where C = length of card*

m = perpendicular distance fram center af cord to centerline ($\mathcal{C}_L$) of rood

R = radius of circle

By fixing m ot any canvenient distance, such as 5 feet, the formula becomes .. $R = C^2/40 + 2.5$

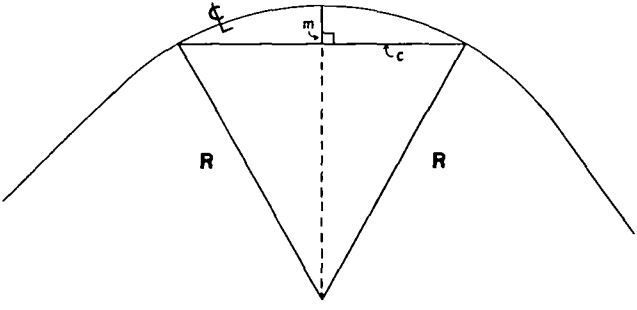


Figure 176. Measuring a curve using formula $R = C^2/8m+m/2$.

Table 85. Criteria for Determination of Limiting Factors

Limiting Factor	Criteria	Symbol
Sharp curves	Sharp curves with radius less than 100 ft (30 m) cause some slowing of convoy traffic and will in addition be reported as obstructions.	c
Steep gradients	Steep gradients, 7% or steeper, cause some slowing of of convoy traffic. Gradients steeper than 7% and excessive changes in gradients will, also be reported as obstructions.	g
Poor drainage	Inadequate ditches, crown/camber, or culverts; culverts and ditches blocked or otherwise in poor condition.	d
Weak foundation	Unstable, loose or easily displaced material.	f
Rough surface	Bumpy, rutted, or potholed to an extent likely to reduce convoy speeds.	s
Excessive camber or superelevation.	Falling away so sharply as to cause heavy vehicles to skid or drag toward the road side.	j

Table 86. Symbals far Types af Surface Materials

Symbol	Material	Normal road type
k	Concrete	Type (X); generally heavy duty
kb	Bituminous or aspholtic concrete (bituminous plant mix).	Type (X); generally heavy duty
p	Poving brick ar stone	Type (X); generally heovy duty
rb	Bitumen-penetroted mocodam; woterbaund mocadam with superficial aspholt or tar cover.	Type (X) or (Y); generally medium duty
r	Waterbound mocodam, crushed rock, or corol.	Type (Y); generally light duty
l	Grovel or lightly metalled surface.	Type (Y); generally light duty
nb	Bituminaus surface treatment on naturol eorth, stabilized soil, sand-clay, or other select material.	Type (Y) or (Z); generolly light duty
n	Natural earth, stabilized soil, sand-clay, shell, cinders, disintegrated gronite, or other select moterial.	Type (Z); generolly light duty
v	Voriaus other types not mentioned above.	(indicote length when this symbol is used.)

NOTE: In addition to the symbols shown above, the symbol "b" (bituminous surface) moy be used olane when the type of bituminous construction cannot be determined.

In applying the formula, m is measured from the centerline of the curve toward the estimated center of the circle and then C is measured perpendicularly to m, making sure that C is centered on m. If C is measured at 18 meters -- R = 26.8 meters.

* Rule of thumb. If C is 19 meters or more, it need not be reported.

(5) Determining road gradient

$$\frac{\text{Vertical distance}}{\text{Horizontal distance}} \times 100 = \%$$ of slope or you may use a clinometer if one is available.

(6) The road reconnaissance report has the information required for classification of a road. There should be several copies, each covering a selected section of the road. Short forms or worksheets may be designed for rapid field work. (See FM 5-36).

c. Bridge Reconnaissance.

(1) The limiting features of bridges are of basic importance to the selection of a route for normal troop movements. (See tables 87 and 88.)

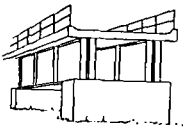
(2) Bridge reconnaissance has two methods.

(a) Hasty reconnaissance determines immediate trafficability.

(b) Deliberate reconnaissance is done when there is enough time and qualified personnel to make a thorough analysis and classification of the bridge, including necessary repairs or demolition procedures.

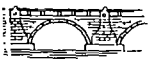
(3) Full bridge symbol includes the location of the bridge, the arbitrarily assigned bridge number, the military local classification number, the overall length of the bridge, the roadway width, the vertical clearance, and the bridge bypasses. Horizontal clearance, under-bridge clearance, number of spans, type of span construction, type of span construction material, and length and condition of spans (fig. 177 and 178). Information should be obtained to complete the Bridge Report Form (DA Form 1249).

TRUSS

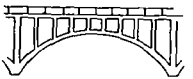


GIRDER

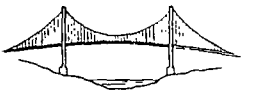
SLAB



(Closed Spondrel)



ARCH (Open Spondrel)



SUSPENSION

STEEL STRINGER

CANTILEVER

Bridge Number Symbols

Type of Span	Number Symbol
Truss	1
Girder	2
Beam	3
Slab	4
Arch (closed spandrel)	5
Arch (open spandrel)	6
Suspension	7
Floating	8
Others	9

Construction Material Symbols

Material of Span Construction	Letter Symbol
Steel, or other metal	a
Concrete	k
Reinforced concrete	ak
Prestressed concrete	kk
Stone or brick	p
Wood	n

Figure 177. Common types of span construction.

Table 87. General Dimension Data Required for Each of the Seven Basic Types of Bridges

Dimension data	Simple stringer	Slab	T-beam	Truss	Girder	Arch	Suspension
Overall length.	x	x	x	x	x	x	x
No. of spans	x	x	x	x	x	x	x
Length of spans.	x	x	x	x	x	x	x
Panel length	---	---	---	x	---	---	x
Height above streambed .	x	x	x	x	x	x	x
Height above estimated normal water level. . .	x	x	x	x	x	x	x
Width of roadway	x	x	x	x	x	x	x
Vertical clearance (over) .	---	---	---	x	---	---	x
Horizontal clearance. . .	x	x	x	x	x	x	x

NOTE: The letter "x" indicates that the dimension is required.

(4) Bridge bypasses are local detours, which are classified as easy, difficult, or impassable. Figure 174 shows the symbols used for each classification.

(a) Bypass easy is a local detour by road or cross-country movement which all types of traffic can make in 15 minutes or less, or 4 miles (6.5 km) added to the direct route distance. It should require less than 4 hours for 35 men, with proper equipment, to improve or construct.

(b) Bypass difficult differs from bypass easy in that more than 4 hours are required for 35 men, with proper equipment, to improve or construct.

(c) Bypass impassible exists when --

1. No alternative bridge is available within acceptable distance.
2. Terrain prevents off-road movement or temporary road construction.
3. Characteristics of the stream prohibit fording or construction of temporary crossing means.
4. Depth or slope of obstacle prohibits construction of approaches to crossing site.

(5) The Bridge Reconnaissance Report (DA Form 1249) is used to report bridge information. Short forms or worksheets may be used by reconnaissance units when time is short. (See FM 5-36).

Table 88. Capacity Dimension Data Required for Each of the Seven Basic Types of Bridges.

Capacity (1) dimension data	Basic types of bridge										
	Simple stringers					Slab	T-beam	Truss	Girder	Arch	Suspension
Thickness of wearing surface	x					x	x	x	x	x	x
Thickness of flooring, deck, or depth of fill at crown	x					x	x	x	x	x	x
	Timber		Steel								
	Rectang.	Log	I-beam	Channel	Rail						
Distance, c-to-c, between T-beams, stringers, or floor beams	x	x	x	x	x		x	x	x	x	x
No. of T-beams or stringers	x	x	x	x	x		x	x	x		x
Depth of each T-beam or stringer	x	(2)	x	x	x		x	x	x		x
Width of each T-beam or stringer	x		(3)	(3)	(3)		x	x	x		x
Thickness of web of I-beams, WF-beams, channels, or rails			x	x	x			x	x		x
Sag of cable											x
No. of each size of cable											x
Thickness of arch ring										x	
Rise of arch										x	
Diameter of each size of cable											x
Depth of plate girder									x		
Width of flange plates									x		
Thickness of flange plates									x		
No. of flange plates									x		
Depth of flange angle									x		
Width of flange angle									x		
Thickness of flange angle									x		
Depth of web plate									x		
Thickness of web plate									x		
Average thickness of flange			x								

Note "x" indicates required dimension

1 Capacity is computed by the use of formulas and data in bridge manuals

2 Diameter

3 Width of flange

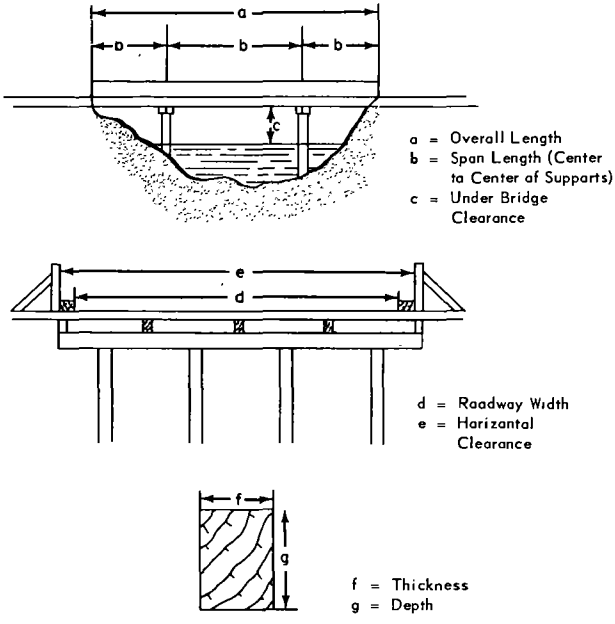


Figure 178. Typical timber cross section.

d. **Tunnel Reconnaissance.** Because tunnels are sometimes used for storage, maintenance assembly, or other purpose, their limiting features must be known. The required information (DA Form 1250) is pointed out in FM 5-36.

e. **Ford Reconnaissance.**

(1) Classification of fords. Fords are classified according to their crossing potential for foot, wheeled, or tracked movement.

(a) Their trafficability is indicated for vehicles and foot troops in table 89.

(b) Approaches may be paved with concrete or bituminous material, although they are usually just sand or gravel. The composition and slope of the approach are important; its trafficability in inclement weather depends upon them.

(c) The composition of the stream bottom determines its passability. It is important, therefore, to indicate it.

(d) The stream bottom at a ford has been paved, in some cases, to improve its load-bearing capacity and to reduce the stream's depth. The paved area may be of concrete, gravel, layers of sandbags, steel mats, or wooden planks.

(e) Seasonal floods, excessively dry periods, freezing, and other extreme conditions af weather affect the fordability of a stream

(f) Swiftness of the current and presence of debris affect passability of a ford. Current is recorded as swift (over 5 feet per second), moderate (1 to 1.5 meters per second), or slow (less than 1 meter per second).

(g) Dimensional data of a ford are pointed out in figure 179.

(2) Stream width.

(a) With a compass, determine the azimuth from a point on the near shore close to the water's edge to a point near the water's edge on the far shore of the stream directly opposite. Then another point, either upstream or downstream from the previously marked points, is established on the near shore, from which the azimuth to the point on the far shore is 45° at variance with the previously marked azimuth. The distance between the two points on the near shore is equal to the distance across the stream (fig. 180).

(b) Stretch a string across the stream, then measure the distance on the string. A measuring tape may be used if one long enough is available.

Table 89. Trafficability of Fords

Type of traffic	Fordable depth, m [1]	Min width, m	Type of bottom	Max desirable slope an approaches [2]
Foot.	1	1= (single file) 2= (column of 3's).	Firm enough to prevent sinking.	1:1
Trucks and truck-drawn artillery .	.6	3.6		3:1
Light tank	.3 to 1	4.2	Firm	2:1
Medium tanks.	.6 to 1.2	4.2	and	2:1
Heavy tanks	1.2 to 1.8	4.2	smooth.	2:1

[1] Moderate current.

[2] Based on hord, dry surface. If wet and slippery, slope must be less.

(3) Stream velocity. Stream velocity is calculated by measuring a distance along the riverbank, then determining the time it takes a light object to float this measured distance (fig. 180). Velocity is computed as follows:

$$\frac{\text{Measured distance (m)}}{\text{Time (sec)}} = \text{velocity in meters per second.}$$

(4) Ford reconnoissance report. This report is made on DA Form 1251, Ford Reconnaissance Report. Short forms or worksheets may also be used.

f. Ferry Recannaissance. Ferries actually differ widely in appearance, capacity, propulsion, construction, and so on. For information on ferry reconnaissance, see FM 5-36.

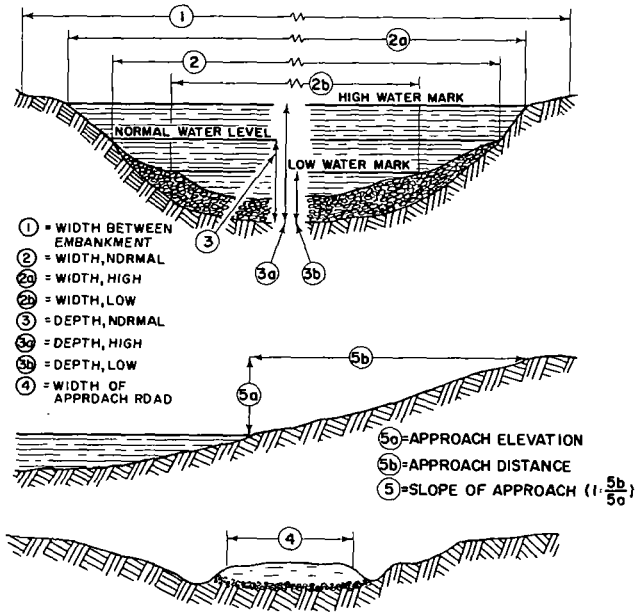
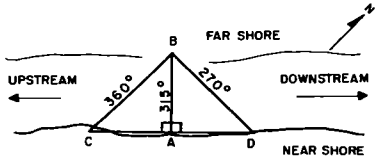


Figure 179. Standard dimensional data for fords.

g. **Water Reconnoissance.**

(1) Location of water source. This always involves field reconnoissance, with a brief study of a map.

(2) Sources. When troops are in combat and moving rapidly, usually there isn't time to search for the best water, and units must take whatever is available and purify it with material at hand. The principal sources are:



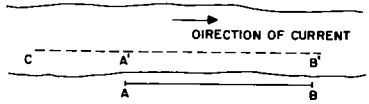
ADD 45° TO
AB AZIMUTH
TO GET AZIMUTH
OF CB

SUBTRACT 45°
FROM AB AZIMUTH
TO GET AZIMUTH OF
BD

WHEN TURNING 90° TO THE LEFT,
ADD 45° TO THE A TO B AZIMUTH TO
GET THE C TO B AZIMUTH.

WHEN TURNING 90° TO THE RIGHT,
SUBTRACT 45° FROM THE A TO B
AZIMUTH TO GET THE C TO B AZIMUTH.

1 MEASURING STREAM WIDTH, USING A COMPASS.



DISTANCE AB IS MEASURED
FLOATING OBJECT IS THROWN INTO STREAM AT C
TIME REQUIRED FOR FLOATING OBJECT TO FLOAT
DISTANCE A'B' IS DETERMINED

$$V(FPS) = \frac{AB\ (FEET)}{TIME\ TO\ FLOAT\ A'B'\ (SEC)}$$

2 DETERMINING STREAM VELOCITY

Figure 180. Methods of measuring stream width and velocity.

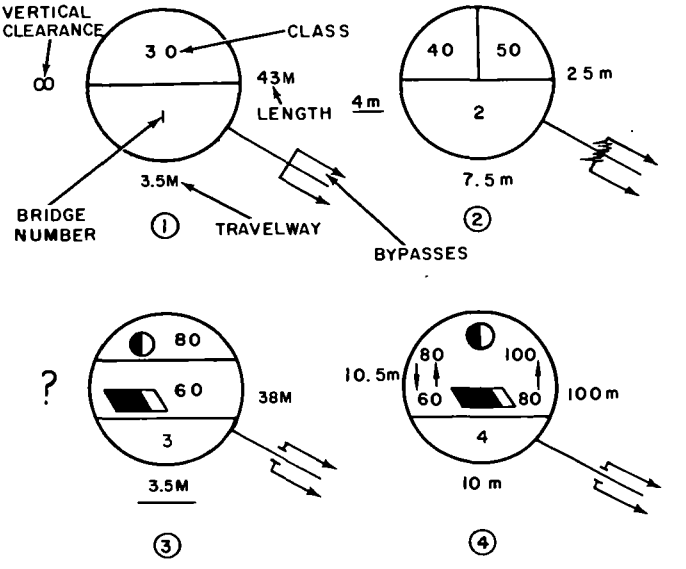


Figure 181. Examples of the full bridge symbol.

(a) Surface water (streams, lakes, and ponds).
(b) Springs.
(c) Wells.
(d) Sea water.
(e) Rain.
(f) Snow and ice.

(3) Capacity of source (quantity). It is necessary to compute the minimum, average, and maximum flow of streams, wells, or springs, and the dimensions, and depths of lakes or ponds, with their rate of outflow. The amount of water that passes a point in one minute is determined as follows:

$$Q = A \times V \times 7.5 \times .85$$

Where A = Cross-section area of stream

V = Flow in ft/min.

7.5 = No. of gals. of water per cu. ft.

.85 = Friction loss constant

(4) Quality of water. Check the color, turbidity, odor, taste, and possible pollution. In a pollution check, examine the drainage area, as much as time permits, for human wastes, industrial wastes, carrion, or poisoning by enemy action.

(5) Tests. Tests are performed by personnel operating water points.

(6) Accessibility. There should be a road system connecting a water supply with the users.

(7) Proposed development. Compute the time, labor, and material necessary to improve the site.

(8) Data from local inhabitants, local records, and soil surveys. If a water source is to be used for some time, information must be obtained on seasonal variations, seasonal floods, seasonal drought, and additional sources.

(9) The above data should be reported on pertinent maps with the conventional military symbols and signs described in FM 21-30.

h. Water Supply. Quantities of water required per man per day are written in table 90.

i. Airfield Reconnaissance. See section II, Chapter 7.

Table 90. Per Capita Water Consumption in a Theater of Operations

Situation	Gals.	Remarks
Troops in combat	½	Absolute minimum, drinking only, not over 3 days.
	1	A small additional allowance for cooking.
March or bivouac	2	Minimum for drinking, cooking, washing mess utensils, hands, and face.
	5	Allows in addition some bathing and laundry.
Temporary camp	5	Minimum, see preceding.
	15	Includes bathing and waterborne sewage on an economy basis.
Semipermanent camp	30-60	
Cantonment (theater)	60-100	
Hospital	10*	Minimum.
	50*	Allows for waterborne sewage.

*Per bed.

87. SYMBOLS FOR OVERLAYS

a. **Bridge Symbols.** See figures 173, 174, 177, and 181.

b. **Tunnel Symbols.** Tunnel data is largely the standard dimensional data written on the report form (DA 1250).

c. **Ford Symbols.** Ford data is mainly the dimensional data given on the report form (DA form 1251).

d. **Ferry Symbols.** This data is the type of measurements required by DA form 1252.

e. **Water Supply Symbols.** Water-source and water-supply data may be recorded on a map or overlay, using the appropriate symbol as given in FM 21-30.

f. **Airfield Symbols.** Abbreviations, symbols, and notations as used for route reconnaissance (par 86a) are useful in airfield reconnaissance.

g. **Minefield Symbols.** The symbols used in the sketches and reports of minefields are as given in paragraph 30 above.

Section II. Map Symbols and Conversions

88. UNIT DESIGNATION

a. **Combining Symbols.** The arrangement of the combination of basic symbols, letters, numbers, and abbreviations to show any specific troop unit, observation point, or military installation is shown as follows.

Size

X 1

X	X	X	X	Branch[2]	X	X	X
Sub-sub-sub-sub-unit	Sub-sub sub unit	Sub-sub unit	Sub unit	(Type) (Caliber of weapons)	Parent unit	Add'l info	Explanatory info

1. The symbol ▭ denotes troop unit; other symbols, such as △ for observation post and ○ for various supply and service installations, are also used.
2. Branch applies only to troop unit; other basic symbols, such as ▼ for class III supply, would be used for other types of figures.

▭ Troop unit

▭ + branch symbol (✕) = ⊠ = infantry unit

⊠ + size symbol (•) = • ⊠ = infantry squad

⊠ + parent unit (31) = • ⊠ 31 = squad of 31st Infantry

⊠ 31 + sub unit (2) = 2 • ⊠ 31 = squad of 2d Battle Group, 31st Infantry

2 ⊠ 31 + sub sub unit (Company C) = C2 • ⊠ 31 = squad of Co. C, 2d Battle Group, 31st Infantry

C2 ⊠ 31 + sub-sub-sub-unit (1st platoon) = 1C2 • ⊠ 31 = squad of 1st platoon, Co. C, 2d Battle Group, 31st Infantry

1C2 ⊠ 31 + sub-sub-sub-sub-unit (3d squad) = 31C2 • ⊠ 31 = 3d squad, 1st platoon, Co. C, 2d Battle Group, 31st Infantry

31C2 ⊠ 31 + additional info (Atch Co. B) = 31C2 • ⊠ 31 (Atch Co. B) = 3d squad of 1st platoon, Co C, 2d Battle Group, 31st Infantry (Attached to Co. B)

The reading of the final symbol is: 3d Squad of the 1st Plataan, Campany C, 2d Battle Graup, 31st Infantry (Attached ta Campany B).

b. Units.

Airbarne	
Air Farce	
Army aviatian units	
Armar	
Artillery	
Antiaircraft artillery	
Cavalry (mechanized)	
Chemical Carps	
Engineer	
Infantry	
Medical	
Civil Affairs	
Military Palice	
Ordnance	
Quartermaster	
Signal	
Transpartatian	
Veterinary	

NOTE: At times 2 af the abave symbols may be cambined. Far example, the armared infantry would cambine the symbal far armar and infantry ( )

c. Size of Units.

Squad	●
Sectian	●●
Plataan	●●●
Detachment	●●●
Company, traop, battery, ar air flight	I
Battalian, ar squadran	II
Regiment, graup, ar air graup	III

Brigade, combat command, or equivalent	X
Division	XX
Corps	XXX
Army, or oir force	XXXX
Army group, or air command	xxxxx
Area command of CommZ section	O O
Area command or logistical command headquarters of a section of CommZ	O O O
Theater army logistical command headquarters	O O O O

89. MAP DISTANCE CONVERSION

Table 91 shows the equivalents of map distance and ground distance.

Table 91. Map-Distance Conversion

Map distance	Ground distance	Representative fraction (RF)							
		1/25,000	1/50,000	1/75,000	1/100,000	1/200,000	1/250,000	1/500,000	1/1,000,000
One inch	Inches	25,000	50,000	75,000	100,000	200,000	250,000	500,000	1,000,000
	Feet	2,083	4,167	6,250	8,333	16,667	20,833	41,667	83,333
	Yards	694	1,389	2,083	2,778	5,555	6,944	13,888	27,776
	Meters	635	1,270	1,905	2,540	5,080	6,350	12,700	25,400
	Miles	0.4	0.8	1.2	1.6	3.2	4	8	16
	Kilometers	.64	1.3	1.91	2.54	5.08	6.35	12.7	25.4
One centimeter	Inches	9,843	19,685	29,528	39,370	78,740	98,425	196,850	393,700
	Feet	820	1,640	2,460	3,281	6,562	8,202	16,404	32,808
	Yards	273	547	820	1,094	2,187	2,734	5,468	10,936
	Meters	250	500	750	1,000	2,000	2,500	5,000	10,000
	Miles	0.16	0.3	0.5	0.6	1.2	1.5	3	6
	Kilometers	.25	.50	.75	1.00	2.00	2.50	5.00	10.00

CHAPTER 11

USEFUL DATA

Section I. Materials

90. WEIGHTS OF COMMON MATERIALS

Table 92 gives the weights and specific gravities of materials commonly used in an engineer unit. Further information on other materials is found in FM 5-35.

91. WIRE NAILS

Examine table 93 and figure 182 for this information.

92. DRIFTPINS.

a. **Description.** Driftpins are long, heavy, threadless bolts used to hold heavy pieces of timber together. The term "driftpin" is almost universally used in practice, but for supply purposes the correct designation is "driftbolt." Driftpins have heads and vary in diameter from 1/2 to 1 inch, and in length from 18 to 26 inches.

b. **Uses.** To use the driftpin, a hole slightly smaller than the diameter of the pin is made in the timber. The pin is driven into the hole and held in place by the compression action of the wood fibers.

93. WIRE GAGES

Table 101 shows the breaking strengths of different sizes of wire rope.

94. ROOFING

a. **Introduction.** Roofing repairs should be made in clear, mild weather with the outside temperature not below 50°F. Repair minor damages by applying asphalt plastic flashing cement. Layer breaks are repaired by opening the horizontal seam below the break and inserting a strip of roofing.

b. **Materials Required.** Depending on the method used to repair a roof, the quantities and kinds of materials vary.

(1) When 4-inch strips of fabric and asphalt roof coating are used, the quantity of coating for 100 square feet of roofing is 4/5 gallon; 39 linear feet of strips are needed.

(2) When 6-inch strips of roofing, asphalt plastic cement, and asphalt emulsion (clay type) are used, the following quantities per 100 square feet of roofing are used:

Asphalt plastic cement - 6 pounds
Roofing strips - 39 linear feet
Asphalt emulsion - 1 gallon

c. **Other Roofing.** For roofing and repair when asphalt shingles, metal roofing, wood shingles, slats, or tile are used, see TM 5-617.

Table 92. Weights and Specific Gravities

Substance	Weight, lbs per cu. ft.	Specific gravity
Bituminous		
Asphaltum	81	1.1 - 1.5
Coal, anthracite	97	1.4 - 1.7
Coal, bituminous	84	1.2 - 1.5
Coal, coke	75	1.0 - 1.4
Petroleum, gasoline	42	0.66 - 0.69
Tar, bituminous	75	1.20
Building materials		
Ashes, cinders	40 - 45	----------
Cement, portland, loose	90	----------
Cement, portland, set	183	2.7 - 3.2
Coal and cake, piled		
Coal, anthracite	47 - 58	----------
Coal, bituminous, lignite	40 - 54	----------
Coal, charcoal	10 - 14	----------
Coal, coke	23 - 32	----------
Earth, etc., excavated		
Chalk	137	1.8 - 2.6
Clay, damp, plastic	110	----------
Clay, dry	63	----------
Clay and gravel, dry	100	----------
Clay, marl	137	1.8 - 2.6
Earth, dry, loose	76	----------
Earth, dry, packed	96	----------
Earth, moist, loose	78	----------
Earth, moist, packed	96	----------
Earth, mud, flowing	108	----------
Earth, mud, packed	115	----------
Sand gravel, dry, loose	90 - 105	----------
Sand gravel, dry, packed	100 - 120	----------
Sand gravel, wet	118 - 120	----------
Liquids		
Oils, minerals, lubricants	57	0.90 - 0.93
Water, 4° C. (max density)	62.428	1.0
Water, ice	56	0.88 - 0.92
Water, snow, fresh fallen	8	0.125

Table 92. Continued

Substance	Weight, lbs per cu. ft.	Specific gravity
Masonry, ashlar		
Granite, syenite, gneiss	165	2.3 - 3.0
Limestone, marble	160	2.3 - 2.8
Sandstone, bluestone	140	2.1 - 2.4
Masonry, brick		
Pressed brick	140	2.2 - 2.3
Common brick	120	1.8 - 2.0
Soft brick	100	1.5 - 1.7
Masonry, concrete		
Cement, stone, sand	144	2.2 - 2.4
Masonry, dry rubble		
Granite, syenite, gneiss	130	1.9 - 2.3
Limestone, marble	125	1.9 - 2.1
Sandstone, bluestone	110	1.8 - 1.9
Masonry, mortar rubble		
Granite, syenite, gneiss	155	2.2 - 2.8
Limestone, marble	150	2.2 - 2.6
Sandstone, bluestone	130	2.0 - 2.2
Metals, alloys, ores		
Aluminum, cast, hammered	165	2.55 - 2.75
Copper, cast, rolled	556	8.8 - 9.0
Iron, cast, pig	450	7.2
Iron, wrought	485	7.6 - 7.9
Lead	710	11.37
Magnesium alloys	112	1.74 - 1.83
Manganese	475	7.2 - 8.0
Steel, rolled	490	7.85
Zinc, cast, rolled	440	6.9 - 7.2
Minerals		
Asbestos	153	2.1 - 2.8
Bauxite	159	2.55
Rock		
Limestone, marble	165	2.5 - 2.8
Sandstone, bluestone	147	2.2 - 2.5
Riprap, limestone	80 - 85	----------
Riprap, sandstone	90	----------
Riprap, shale	105	----------

Table 92. Continued

Substance	Weight, lbs per cu. ft.	Specific gravity
Solids, various		
Glass, common	156	2.4 - 2.6
Hay and straw (bales)	20	----------
Paper	58	0.70 - 1.15
Potatoes, piled	42	----------
Rubber goods	94	1.0 - 2.0
Salt, granulated, piled	48	----------
Sulfur	125	1.93 - 2.07
Wool	82	1.32
Stone, quarried, piled		
Basalt, granite, gneiss	96	----------
Greenstone, hornblende	107	----------
Limestone, marble, quartz	9	----------
Sandstone	82	----------
Shale	92	----------
Excavations in water		
Clay	80	----------
River mud	90	----------
Sand or gravel	60	----------
Sand or gravel and clay	65	----------
Soil	70	----------
Stone riprap	65	----------
Timber, U. S. seasoned (Moisture content by weight: seasoned timber, 15% to 20%; green timber, up to 50%)		
Ash, white, red	40	0.62-0.65
Cedar, white, red	22	0.32-0.38
Chestnut	41	0.66
Cypress	30	0.48
Elm, white	45	0.72
Fir, Douglas spruce	32	0.51
Fir, eastern	25	0.40
Hemlock	29	0.42-0.52
Hickory	49	0.74-0.84
Locust	46	0.73
Maple, hard	43	0.68
Maple, white	33	0.53

Table 92. Continued

Substance	Weight, lbs per cu. ft.	Specific gravity
Oak, chestnut	54	0.86
Oak, live	59	0.95
Oak, red, black	41	0.65
Oak, white	46	0.74
Pine, Oregon	32	0.51
Pine, red	30	0.48
Pine, white	26	0.41
Pine, yellow, longleaf	44	0.70
Pine, yellow, shortleaf	38	0.61
Poplar	30	0.48
Redwood, California	26	0 42
Spruce, white, black	27	0.40-0.46
Walnut, black	38	0.61
Walnut, white	26	0.41

95. PAINT

a. **Paint Materials.** For details on which type of paint should be used for a specific job, see the paint manual published by National Bureau of Standards, or TM 5-618.

b. **New Work (Exterior) on Wood Surfaces.**

(1) For the priming coat, the paint comes in cream or grey. Normally, it requires no thinner, but in cold weather thinner may be necessary, in this case, use ½ pint of turpentine added to 1 gallon paint.

(2) Apply unthinned paint at a spreading ratio of about 450 square feet per gallon if it is to be followed by one coat of finish paint. For three-coat work, thin the priming paint as instructed in (1) above, then apply at 600 square feet per gallon.

(3) For the finish coat where a three-coat job is required, apply the paint at the ratio of 600 to 700 square feet per gallon. In good weather, a 48-hour drying period between coats is sufficient. For two-coat work, a spreading rate of about 550 square feet per gallon is required.

c. **Exterior Metal Surfaces.**

(1) For finishing coats, use oil paint or enamel similar to that used for wood. For new steel bridges, apply two finish coats.

(2) Before painting metal, clean off all grease, rust, loose mill scale, dirt, and other foreign matter.

(3) The priming coat should contain a corrosion-inhibitive paint. Allow 2 days to dry.

Table 93. Wire-Nail Sizes, Wire Gages, and Number Per Pound

Size	Length, in	Common		Siding		Finishing		Flooring		Fence	
		Gage	No./lb	Gage	No./lb	Gage	No./lb	Gage	No./lb	Gage	No./lb
2d . .	1	15	876	15½	1,010	16½	1,351	. . .	. . .	. . . .	. . . .
3d . .	1¼	14	568	14½	635	15½	807	. . .	. . .	. . . .	. . . .
4d . .	1½	12½	316	14	473	15	584	. . .	. . .	. . . .	. . . .
5d . .	1¾	12½	271	14	406	15	500	. . .	. . .	10	142
6d . .	2	11½	181	12½	236	13	309	11	157	10	124
7d . .	2¼	11½	161	12½	210	13	238	11	139	9	92
8d . .	2½	10¼	106	11½	145	12½	189	10	99	9	82
9d . .	2¾	10¼	96	11½	132	12½	172	10	90	8	62
10d . .	3	9	69	10½	94	11½	121	9	69	7	50
12d . .	3¼	9	63	. . .	. . .	11½	113	8	54	6	40
16d . .	3½	8	49	. . .	. . .	11	90	7	43	5	30
20d . .	4	6	31	. . .	. . .	10	61	6	31	. . . .	. . . .
30d . .	4½	5	24	. . .	. . .	. . .	. . .	. . .	. . .	. . . .	. . . .
40d . .	5	4	18	. . .	. . .	. . .	. . .	. . .	. . .	. . . .	. . . .
50d . .	5½	3	15	. . .	. . .	. . .	. . .	. . .	. . .	. . . .	. . . .
60d . .	6	2	11	. . .	. . .	. . .	. . .	. . .	. . .	. . . .	. . . .

Note 1. To avoid splitting, nail diameters should not exceed one-seventh of the thickness of lumber to be nailed.

2. Gages are U. S. Steel Wire Gage. Fractional gages are:

Gage	10¼	10½	11½	12½	14½	15½
Diameter, in . .	0.1314	0.1278	0.1130	0.0985	0.0760	0.0673

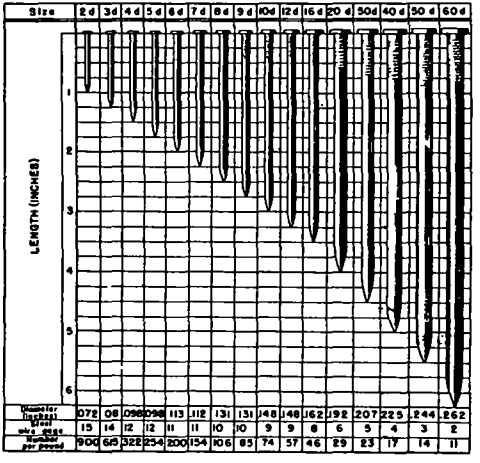


Figure 182. Size, type, and use of nails.

d. Interior Wood Surfaces. Apply only one primer coat and one finish coat. Two finish coats may be applied if primer and first finish coats have been thinly applied. Allow 18 hours between coats.

Section II. Math and Physics Data

96. LENGTHS, AREAS, AND VOLUMES OF GEOMETRIC FIGURES

a. Legend.

A = area
a = altitude
r = radius
D = diameter

b. Formulas.

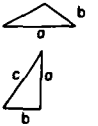
(1) Any triangle: $A = \frac{1}{2} o b$

(2) Right triangle:

$o = \sqrt{c^2 - b^2}$

$b = \sqrt{c^2 - a^2}$

$c = \sqrt{a^2 + b^2}$



(3) Circle:

$A = \pi r^2$

$A = 0.7854 D^2$

$C = \pi D$

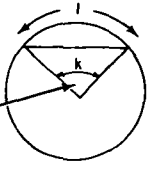
(4) Segment of circle:

$A = \frac{1}{2} [r (1 - k) + ak]$

$l = \left(\frac{2\pi r}{360} \right) \times o$

$k = \sqrt{2or - o^2}$

o = angle in degrees



(5) Sector of circle:

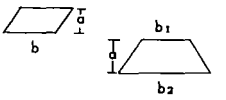
$A = \frac{rl}{2} = \frac{\pi r^2}{360}$ (angle in degrees)

(6) Regular polygons. The area of any regular polygon (all sides equal, all angles equal) is equal to the product of the square of the length of one side

ond the foctors shown in toble 94. Example: Areo of a regulor octogon hoving 6-inch sides is 6 x 6 x 4.828, or 173.81 squore inches. See factors in table 94.

(7) Rectangle and parallelogram:

$A = a\,b$



(8) Trapezoid:

$A = \frac{1}{2}\, a(b_1 + b_2)$

(9) Irregulor figures. Meosure widths ot offsets regularly spoced along any straight line, ond apply one af the following:

(a) Trapezoidol rule. A = one holf the i.nterval between offsets x (sum of twa end widths plus twice the sum of the intermediate width s).

(b) Simpson's rule. (Assumes laterol boundaries are parabolic curves.) A = ane third the intervol between offsets x [sum af twa end widths plus twice the sum of the odd widths, except first and last (3rd, 5th, 7th, etc.) plus 4 times the sum af the even widths (2d, 4th, 6th, etc.)]

NOTE. The above rule requires on odd number of widths. If there is an even number, compute separately the area of a tropezaid at ane end.

Table 94. Polygon Foctors

No. af sides	Factor		No. of sides	Factor
3	0.433		8	4.828
4	1.000		9	6.182
5	1.720		10	7.694
6	2.598		11	9.366
7	3.634		12	11.196

(10) Cube:

$V = b^3$

(11) Rectangular parallelepiped:

$V = a\ b_1\ b_2$

(12) Prism or cylinder:

$V = a$ X (area of base)

(13) Pyramid or cone:

$V = 1/3\ a$ X (area of base)

(14) Sphere:

$$V = 4/3\pi r^3 = \frac{\pi D^3}{6}$$

$A = 4\pi r^2$

(15) Prismoidal section:

V = one sixth the length X (sum of the end areas plus 4 times the midsection area)

97. TRIGONOMETRIC SOLUTION OF TRIANGLES

Examine table 95 for this information.

98. NATURAL TRIGONOMETRIC FUNCTIONS

These functions are listed in tabular form (table 96).

99. FUNCTIONS OF NUMBERS

The squares, square roots, cubes, and logarithms of 1 through 100 are listed in table 97.

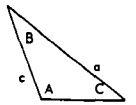
100. CONSTANTS

$g = 32.2$ ft/sec	$\pi^2 = 9.8696$
$\pi/2 = 1.5708$	$1/\pi^2 = 0.1013$
$\pi/3 = 1.0472$	$\sqrt{\pi} = 1.7725$
$2\pi/3 = 2.0944$	$\sqrt[3]{\pi} = 1.4646$
$1/\pi = 0.3183$	

101. FORMULAS

Feet, board measure	= length (ft) x width (ft) x thickness (in)
Velocity of sound in air	= 1090 ft/sec

Table 95. Trigonometric Solutions of Triangles

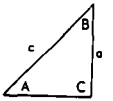


$a^2 = b^2 + c^2 - 2bc\cos A$

$b^2 = a^2 + c^2 - 2ac\cos B$

$c^2 = a^2 + b^2 - 2ab\cos C$

$s = \frac{a+b+c}{2}$



$a^2 = c^2 - b^2$

$b^2 = c^2 - a^2$

$c^2 = a^2 + b^2$

RIGHT TRIANGLE

Given	TO FIND						
	A	B	C	a	b	c	Area
a,b	$\tan A = \frac{a}{b}$	$\tan B = \frac{b}{a}$	90°			$\sqrt{a^2+b^2}$	$\frac{ab}{2}$
a,c	$\sin A = \frac{a}{c}$	$\cos B = \frac{a}{c}$	90°		$\sqrt{c^2-a^2}$		$\frac{a}{2}\sqrt{c^2-a^2}$
A,a		$90^\circ - A$	90°		$a\cot A$	$\frac{a}{\sin A}$	$\frac{a^2\cot A}{2}$
A,b		$90^\circ - A$	90°	$b\tan A$		$\frac{b}{\cos A}$	$\frac{b^2\tan A}{2}$
A,c		$90^\circ - A$	90°	$c\sin A$	$c\cos A$		$\frac{c^2\sin 2A}{4}$

OBLIQUE TRIANGLE

Given	TO FIND						
	A	B	C	a	b	c	Area
a,b,c	$\cos\frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}$	$\cos\frac{B}{2} = \sqrt{\frac{s(s-b)}{ac}}$	$\cos\frac{C}{2} = \sqrt{\frac{s(s-c)}{ab}}$				$\sqrt{s(s-a)(s-b)(s-c)}$
a,A,B			$180^\circ - (A+B)$		$\frac{a\sin B}{\sin A}$	$\frac{a\sin C}{\sin A}$	
a,b,A		$\sin B = \frac{b\sin A}{a}$				$\frac{b\sin C}{\sin B}$	
a,b,c	$\tan A = \frac{a\sin A}{b - a\cos C}$					$\sqrt{a^2+b^2-2ab\cos C}$	$\frac{ab\sin C}{2}$

Table 96. Notural Triganometric Functions

Angle	Sin	Cosec	Tan	Cotan	Sec	Cos	
0°	.000		.000		1 000	1.000	90°
1°	017	57.30	017	57.29	1.000	1.000	89°
2°	.035	28.65	.035	28.64	1.001	.999	88°
3°	.052	19 11	.052	19.08	1.001	999	87°
4°	.070	14.34	070	14.30	1 002	.998	86°
5°	.087	11 47	.087	11 43	1.004	.996	85°
6°	.105	9.567	105	9.514	1.006	.995	84°
7°	.122	8.206	.123	8.144	1.008	.993	83°
8°	.139	7.185	.141	7.115	1.010	990	82°
9°	.156	6.392	.158	6.314	1.012	.988	81°
10°	.174	5.759	.176	5.671	1.015	.985	80°
11°	.191	5.241	194	5.145	1.019	.982	79°
12°	.208	4.810	.213	4.705	1 022	.978	78°
13°	.225	4.445	231	4.331	1.026	.974	77°
14°	.242	4.134	.249	4.011	1.031	.970	76°
15°	.259	3.864	.268	3 732	1 035	.966	75°
16°	.276	3 628	.287	3.487	1.040	.961	74°
17°	.292	3.420	.306	3.271	1 046	.956	73°
18°	.309	3.236	325	3.078	1.051	.951	72°
19°	326	3 072	.344	2.904	1.058	.946	71°
20°	.342	2.924	364	2.747	1.064	940	70°
21°	.358	2.790	.384	2 605	1.071	.934	69°
22°	.375	2.669	404	2 475	1.079	.927	68°
23°	.391	2.559	.424	2.356	1.086	.921	67°
24°	.407	2.459	.445	2 246	1.095	914	66°
25°	423	2.366	.466	2.145	1.103	.906	65°
26°	.438	2 281	.488	2.050	1.113	.899	64°
27°	.454	2.203	.510	1 963	1.122	891	63°
28°	.469	2.130	.532	1.881	1.133	.883	62°
29°	.485	2.063	.554	1.804	1.143	.875	61°
30°	.500	2.000	.577	1.732	1.155	.866	60°
31°	.515	1.942	.601	1 664	1 167	.857	59°
32°	530	1.887	.625	1.600	1.179	848	58°
33°	.545	1.836	.649	1 540	1.192	839	57°
34°	.559	1.788	.675	1 483	1.206	.829	56°
35°	.574	1.743	700	1.428	1.221	.819	55°
36°	.588	1.701	.727	1.376	1.236	.809	54°
37°	.602	1.662	.754	1.327	1.252	.799	53°
38°	616	1.624	.781	1.280	1.269	788	52°
39°	.629	1.589	.810	1 235	1.287	.777	51°
40°	.643	1.556	839	1.192	1.305	.766	50°
41°	.656	1.524	.869	1.150	1.325	755	49°
42°	.669	1.494	.900	1.111	1.346	.743	48°
43°	.682	1.466	.933	1.072	1.367	.731	47°
44°	.695	1.440	.966	1.036	1.390	.719	46°
45°	.707	1 414	1 000	1.000	1.414	707	45°
	Cos	Sec	Cotan	Tan	Cosec	Sin	Angle

Table 97 Functions of Numbers

No.	Square	Cube	Sq. root	Logorithm	No.	Square	Cube	Sq. root	Logorithm
1	1	1	1.0000	0.00000	51	2601	132651	7.1414	1.70757
2	4	8	1.4142	.30103	52	2704	140608	7.2111	1.71600
3	9	27	1.7321	.47712	53	2809	148877	7.2801	1.72428
4	16	64	2.0000	.60206	54	2916	157464	7.3485	1.73239
5	25	125	2.2361	.69897	55	3025	166375	7.4162	1.74036
6	36	216	2.4495	.77815	56	3136	175616	7.4833	1.74819
7	49	343	2.6458	.84510	57	3249	185193	7.5498	1.75587
8	64	512	2.8284	.90309	58	3364	195112	7.6158	1.76343
9	81	729	3.0000	.95424	59	3481	205379	7.6811	1.77085
10	100	1000	3.1623	1.00000	60	3600	216000	7.7460	1.77815
11	121	1331	3.3166	1.04139	61	3721	226981	7.8102	1.78533
12	144	1728	3.4641	1.07918	62	3844	238328	7.8740	1.79239
13	169	2197	3.6056	1.11394	63	3969	250047	7.9373	1.79934
14	196	2744	3.7417	1.14613	64	4096	262144	8.0000	1.80618
15	225	3375	3.8730	1.17609	65	4225	274625	8.0623	1.81291
16	256	4096	4.0000	1.20412	66	4356	287496	8.1240	1.81954
17	289	4913	4.1231	1.23045	67	4489	300763	8.1854	1.82607
18	324	5832	4.2426	1.25527	68	4624	314432	8.2462	1.83251
19	361	6859	4.3589	1.27875	69	4761	328509	8.3066	1.83885
20	400	8000	4.4721	1.30103	70	4900	343000	8.3666	1.84510
21	441	9261	4.5826	1.32222	71	5041	357911	8.4261	1.85126
22	484	10648	4.6904	1.34242	72	5184	373248	8.4853	1.85733
23	529	12167	4.7958	1.36173	73	5329	389017	8.5440	1.86332
24	576	13824	4.8990	1.38021	74	5476	405224	8.6023	1.86923
25	625	15625	5.0000	1.39794	75	5625	421875	8.6603	1.87506
26	676	17576	5.0990	1.41497	76	5776	438976	8.7178	1.88081
27	729	19683	5.1962	1.43136	77	5929	456533	8.7750	1.88649
28	784	21952	5.2915	1.44716	78	6084	474552	8.8318	1.89209
29	841	24389	5.3852	1.46240	79	6241	493039	8.8882	1.89763
30	900	27000	5.4772	1.47712	80	6400	512000	8.9443	1.90309
31	961	29791	5.5678	1.49136	81	6561	531441	9.0000	1.90849
32	1024	32768	5.6569	1.50515	82	6724	551368	9.0554	1.91381
33	1089	35937	5.7446	1.51851	83	6889	571787	9.1104	1.91908
34	1156	39304	5.8310	1.53148	84	7056	592704	9.1652	1.92428
35	1225	42875	5.9161	1.54407	85	7225	614125	9.2195	1.92942
36	1296	46656	6.0000	1.55630	86	7396	636056	9.2736	1.93450
37	1369	50653	6.0828	1.56820	87	7569	658503	9.3274	1.93952
38	1444	54872	6.1644	1.57978	88	7744	681472	9.3808	1.94448
39	1521	59319	6.2450	1.59106	89	7921	704969	9.4340	1.94939

Table 97. Continued

No.	Squore	Cube	Sq. root	Logorithm	No.	Square	Cube	Sq. root	Logorithm
40	1600	64000	6.3246	1.60206	90	8100	729000	9.4868	1.95424
41	1681	68921	6.4031	1.61278	91	8281	753571	9.5394	1.95904
42	1764	74088	6.4807	1.62325	92	8464	778688	9.5917	1.96379
43	1849	79507	6.5574	1.63347	93	8649	804357	9.6437	1.96848
44	1936	85184	6.6332	1.64345	94	8836	830584	9.6954	1.97313
45	2025	91125	6.7082	1.65321	95	9025	857375	9.7468	1.97772
46	2116	97336	6.7823	1.66276	96	9216	884736	9.7980	1.98227
47	2209	103823	6.8557	1.67210	97	9409	912673	9.8489	1.98677
48	2304	110592	6.9282	1.68124	98	9604	941192	9.8995	1.99123
49	2401	117649	7.0000	1.69020	99	9801	970299	9.9499	1.99564
50	2500	125000	7.0711	1.69897	100	10000	1000000	10.0000	2.00000

Ohm's low. volts = amps x ohm
Watt's low: wotts = amps x volts
Kilowott hour = 1000 wott-hours
Degrees centigrade = 5/9 (°F. – 32)

Section III. Strength of Materials

102. MOMENTS

a. **Bending Moments:**

$M = fS$

where f = allowable fiber stress in pounds per square inch
S = section modulus (b below)
M = bending moment. (Multiply by 12 to convert foot-pounds to inch-pounds.)

b. **Section Modulus.**

(1) Rectangular sections:

$$S = \frac{bd^2}{6}$$

where b = width of section in inches
d = depth of section in inches.

(2) Circular sections:

$$S = \frac{d^3}{10}$$

where d = diameter of circle in inches.

(3) Steel beams:

$$S = d_1 \left(Af + \frac{Aw}{6}\right)$$

where, d_1 = depth of beam
Af = area of flange
Aw = cross-sectional area of web

103. WORKING STRESSES FOR AVERAGE TIMBER (DOUGLAS FIR OR SOUTHERN PINE)

a. **Bending:** 2,400.

b. **Shear Parallel to the Grain:** 150.

c. **Bearing Perpendicular to the Grain:** 500.

d. **Modulus of Elasticity:** 1,600,000.

e. **Compression Numbers.**

(1) Short columns, for L/d ratios not greater than 11:

$$f = 1{,}300.$$

(2) Intermediate columns, where L/d ratios are greater than 11 but less than $K = 0.64\sqrt{E/c}$, in which E is the modulus of elasticity and c is the allowable compression stress parallel to the grain:

$$f = c\left[1 - \frac{L}{3Kd}\right]$$

(3) Long columns, for L/d ratios greater than K:

$$f = \frac{0.274c}{(L/d)^2}$$

NOTE: For working stress of all types of timber, see TM 5-312.

104. WORKING STRESSES FOR STEEL (in pounds per sq. in.)

a. **Axial Tension, Net Section:** 27,000.

b. **Tension on Extreme Fiber:** 27,000.

c. **Beams or Stringers in bending:** 27,000 $\quad = \frac{Ld}{b+f} \leq 400.$

d. **Bolts at Root of Thread:** 20,000.

e. **Axial Compression.**

(1) Stiffeners of plate girders: 27,000.

(2) Members with riveted ends, for L/r ratios not greater than 140:

$$f = 21{,}300 - 3/8\,(L/r)^2$$

(3) Members with pinned ends, for L/r ratios not greater than 140:

$$f = 21{,}300 - \tfrac{1}{2}(L/r)^2$$

(4) Splice material, gross section: 27,000

f. *Shear:* (in pounds per sq in.)

(1) Girder webs, gross section: 16,500

(2) Power-driven rivets and pins: 20,000.

(3) Turned bolts: 16,500.

(4) High tensile strength steel bolts. 20,000.

(5) Unfinished bolts: 12,000.

g. Bearing: (in pounds per sq. in.)

(1) On rivets, single shear: 32,000.

(2) On rivets, double shear: 40,000.

(3) On unfinished bolts· single shear. 20,000.

(4) On unfinished bolts: double shear· 25,000.

(5) On milled stiffeners and other steel parts in contact: 40,000.

(6) Expansion rollers and rockers, pounds per linear inch:

(a) For diameters up to 25 inches:

$$\frac{S - 13{,}000}{20{,}000}\ 900d$$

(b) For diameters from 25 to 125 inches:

$$\frac{S - 13{,}000}{20{,}000}\ 4500d$$

in which d is the diameter of the roller or rocker in inches, and S is the tensile yield stress of the roller or base, whichever is smaller.

105. BEAM MOMENTS AND SHEAR FOR VARIOUS LOADINGS

a. Symbols.

A -- area of section
b -- width of section
c -- distance from neutral axis to extreme fiber
d -- depth of section
F -- load in pounds
f -- allowable stress in psi
I -- moment of inertia of section to extreme fiber
L -- span
l -- length in inches

M -- bending moment
R -- reaction
S -- section modulus $\frac{I}{C}$
V -- total shear
v -- unit shear
w -- load per unit of length

b. Maximum Bending Moments and Shear. Moment and shear are shown in table 98.

Section IV. Timber Construction

106. DIMENSIONS AND PROPERTIES

Table 99 gives the dimensions and properties of timber.

107. STRUCTURAL TIMBER DATA

This data is shown in table 100.

108. CARPENTER TOOL KITS

a. For Engineer Squad. This set provides the necessary hand tools for a carpenter to perform basic wood-working and wood construction operations. The components of this set are listed as follows:

Components		Quantity
Bar, wrecking, 30 in.	____	2
Blade, hand hacksaw, 12 in.	____	12
Chalk, marking, blue, 72 per box.	____	1
Chisel, framing, ½ in. wide.	____	1
Crayon, marking, blue, 12 per box.	____	1
Crayon, marking, red, 12 per box.	____	1
File, hand, flat, 12 in., bastard edges and faces.	____	1
File, hand, flat, 8 in., smooth edges and faces.	____	2
Frame, hand hacksaw, adjustable 8 to 12 in.	____	1
Hammer, hand, blacksmith, cross-peen, 3 lb.	____	2
Hammer, carpenter, nail, curved claw, 1 lb.	____	4
Hammer, screw-in face, plastic, 2 lb.	____	1
Handle, file, wood.	____	1
Handle, hammer, wood.	____	2
Hatchet, half, 3½ in. wide edge.	____	2
Level, line, 3 in. long, metal.	____	1

Components	Quantity
Level and plumb, 24 in. long, wood.	1
Plane, smooth, 2 in. wide, 9 in.	1
Pliers, lineman's, side cutter, 8 in.	2
Pliers, slip joint, w/cutter, 8 in.	1
Rasp, hond, 14 in.	1
Rule, multiple folding, aluminum, 6 ft.	2
Saw, hond, crosscut, 26 in. blode.	2
Sow, hand, rip, 26 in. blode.	1
Screwdriver, flat tip, flared, ¼ in. wide, 4 in. blode.	1
Screwdriver, flat tip, flored, 5/16 in. wide, 6 in. blade.	1
Screwdriver, stroight, 3/16 in. wide, 3 in. blode.	1
Squore, carpenter, steel, 16 in.	1
Square, try, wood, steel blade, 8 in.	1
Tope, meosuring, steel, 50 ft.	1
Tool,box, 31 in. x 15 7/8 in. x 8 in.	1
Twine, cattan, 35-lb., breaking strength.	4
Wrench, open end, adjustable, 1 5/16 in. jow.	1

b. Far Engineer Platoon. This set provides hand tools for a carpenter to do general carpentry work, including sowing, drilling, filing, fostening, and some shoping of wood. Its components are:

Components	Quantity
Bar, pinch, 26 in.	1
Bevel, sliding T, 8 in.	1
Bit, ouger, 14½ in., 7/16 in. diameter.	2
Bit, ouger, 17½ in., 5/8 in. diometer.	1
Bit, ouger, 17½ in., 1 in. diometer.	1
Bit, exponsive.	1
Bit, screwdriver, flored, 5 in., 3/8 in. wide.	1
Bit, screwdriver, flared, 5 in., ½ in. wide.	1
Bit set, auger, screw paint, w/roll.	1

Components		Quantity
Bit, auger, ¼ in. diameter.	____	1
Bit, auger, 3/8 in. diameter.	____	1
Bit, auger, ½ in.	____	1
Bit, auger, 3/8 in.	____	1
Bit, auger, 3/4 in.	____	1
Bit, auger, 7/8 in.	____	1
Bit, auger, 1 in.	____	1
Brace, bit, ratchet, 10 in., sweep diameter.	____	1
Chalk, marking, blue, 72 per box.	____	1
Chest, carpenter, 37¼ in. x 22 in. x 9 3/8 in.	____	1
Chisel, cold, hand, 3/4 in. wide, 6½ in.	____	1
Chisel, framing, ¼ in. wide blade.	____	1
Chisel, framing, ½ in. wide blade.	____	1
Chisel, framing, 1 in. wide blade.	____	1
Chisel, framing, 1½ in. wide blade.	____	2
Countersink, pilotless, 5/8 in. diameter.	____	1
Dividers, mechanic's, steel, 8 in. long.	____	1
Drill, hand, single speed.	____	1
Drill set, twist, high speed, steel.	____	1
Drill, twist, 1/16 in.	____	1
Drill, twist, 3/32 in.	____	1
Drill, twist, 1/8 in.	____	1
Drill, twist, 5/32 in.	____	1
Drill, twist, 3/16 in.	____	1
Drill, twist, 7/32 in.	____	1
Drill, twist, ¼ in.	____	1
Drill, twist, 9/32 in.	____	1
File, hand, auger bit, 7 in.	____	2
File, hand, flat, 8 in.	____	2
File, hand, regular taper, 6 in.	____	3

Components		Quantity
File, hand, slim taper, 6 in.	____	3
Hammer, hand, carpenter, nail, curved claw, 1 lb.	____	9
Hammer, hand, screw-in face, plastic, 2 lb.	____	2
Handle, auger, wood, 17 in.	____	3
Handle, chisel and gauge, 5½ in.	____	4
Handle, file, wood, 4 in.	____	4
Handle, file, wood, 4½ in	____	2
Handle, hammer, wood, 14 in.	____	9
Handle, hatchet, 14 in.	____	6
Hatchet, half, 3½ in. wide edge, 14 in.	____	3
Level, line, metal, 3 in.	____	1
Level and plumb, wood, 24 in.	____	1
Nail set, 3/32 in. diameter point.	____	1
Oiler, hand, 12 oz., straight, 5 3/4 in.	____	1
Pencil, carpenter, black, hard, 7 in.	____	1
Plane, jack, 2 in. cutter, 14 in.	____	1
Pliers, slip joint, w/cutter, 5 in.	____	1
Plumb bob, steel, 8 oz.	____	1
Rasp, hand, half round, wood, 14 in.	____	1
Rule, multiple folding, aluminum, 6 ft.	____	4
Saw, hand, crosscut, 26 in.	____	5
Saw, hand, rip, 26 in.	____	1
Saw set, hand, single plunger.	____	1
Saw, nested.	____	1
Blade, compass saw, 12 in.	____	1
Blade, keyhole saw, 10 in.	____	1
Blade, plumber's saw, 16 - 18 in.	____	1
Handle, saw, wood, pistol grip, drilled.	____	1
Screw, wood, steel, flat head, slot drive, 2 3/4 in.	____	144
Screw, wood, steel, flat head, slot drive, 1½ in.	____	144
Screw, wood, steel, flat head, slot drive, 1¼ in.	____	144

Components		Quantity
Screw, wood, steel, flat head, slot drive, 7/8 in.	_____	144
Screwdriver, cross tip, Phillips, 3 in. blade.	_____	1
Screwdriver, cross tip, Phillips, 6 in. blade.	_____	1
Screwdriver, flat tip, flared, ¼ in. tip, 4 in. blade.	_____	1
Screwdriver, flat tip, flared, 5/16 in. tip, 6 in. blade.	_____	1
Screwdriver, flat tip, flared, 7/16 in. tip, 8 in. blade.	_____	1
Screwdriver, flat tip straight, 3/16 in. tip, 3 in. blade.	_____	1
Square, carpenter, steel, 16 in. tongue, 24 in. body.	_____	2
Square, combination, steel; scriber and level, 12 in.	_____	1
Square, try, wood, steel blade, 8 in.	_____	2
Stone, sharpening, 8 in.	_____	1
Tape, measuring, steel, 50 ft.	_____	1
Twine, cotton, 35-lb. strength.	_____	3
Vise, handsaw, filing.	_____	1

109. PIONEER TOOL KITS

a. **For Engineer Squad.** This set provides the necessary hand tools for clearing land, building emplacements, and general engineer manual labor. The components are:

Components		Quantity
Ax, single bit, 4 3/4 in. edge, 34½ in. long.	_____	3
Bag, sand, burlap.	_____	3
Block, tackle, 1¼ ton, ordinary, 2 iron sheaves.	_____	2
Block, tackle, 2¼ ton, snatch, 1 iron sheave.	_____	1
Bush hook, hand, 10 3/4 in. blade, 36 in. handle.	_____	2
Chest, pioneer equipment, 40 3/16 in. x 17 3/16 in. x 16½ in.	_____	1
Chest, pioneer equipment, 65¼ in. x 17 3/8 in. x 16½ in.	_____	1
Crowbar, pinch point, 59 to 62 in. long.	_____	1
Cutter, bolt, rigid head, 22 in. long.	_____	1
Digger, posthole, hinged, 2 handles, 60 in. long.	_____	1
Hammer, hand, blacksmith's, double faced, 8 lb.	_____	2
Jack, hydraulic, hand, self-contained, 12 ton.	_____	1
Level, line, metal, 3 in.	_____	1

Components		Quantity
Machete, rigid handle, 18 in. blade.	____	2
Marline, hemp, tarred, 160 lb. strength.	____	10
Nail, common, wire, flat head, 2½ in long, 8d.	____	5 lb.
Nail, common, wire, flat head, 3½ in. long, 16d.	____	10 lb.
Nail, common, wire, flat head, 4½ in. long, 30d.	____	30 lb.
Nail, common, wire, flat head, 6 in. long. 60d.	____	30 lb.
Pick, digging, 7 lb.	____	3
Pliers, slip joint, w/cutter, 8 in.	____	2
Rope, manila, 5400 lb. strength, 6 ft. per lb.	____	50 lb.
Saw, crosscut, two man, 5 ft.	____	1
Shears, metal cutting, hand, 13 in.	____	1
Shovel, hand, D-handle.	____	3
Shovel, hand, long handle.	____	3
Tape, textile, cotton, 36 yd.	____	10
Trip wire grapnel, steel, 3 prang.	____	2
Trowel, brick.	____	2
Trowel, cement.	____	1
Twine, cattan, 35 lb. strength.	____	2
Vise, machinist's, swivel base.	____	1
Wedge, timber, splitting, flared bit.	____	2
Wire, steel, carbon, 5 lb. reel.	____	10 lb.

b. Far Engineer Platoon. This set contains hand tools to be used for clearing land, building emplacements and fortifications, and other types of manual labor. Its components are:

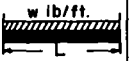
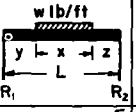
Components		Quantity
Adz, full head, 3 to 5 lb., 3½ to 4½ in. edge.	____	2
Auger, posthole, hand, adjustable blade.	____	2
Ax, single bit, 4 lb. head, 4 3/4 in. edge.	____	1
Bar, wrecking, gooseneck and pinch point, w/claw, 30 in. long.	____	1
Bar, wrecking, gooseneck and pinch point, w/claw, 48 in. long.	____	1
Bar, wrecking, pinch point and claw, 30 in. long.	____	1

Components		Quantity
Belt, safety, industriol, leather, lineman's, 22 in.	____	1
Blade, hand hacksow, 12 in.	____	12
Block, tockle, 3/4 ton, fiber rope, 1 iron sheave.	____	2
Block, tackle, 1¼ ton, fiber rope, 2 iron sheaves.	____	4
Block, tockle, 2¼ ton, fiber rope, 1 iron sheove.	____	2
Bolt, drift, steel, square head, cane point, 16 in.	____	80
Box, tool grinder, 18 in. x 14 in. x 8 in.	____	1
Bush hook, hond, 10 3/4 in. blade, 36 in. hondle.	____	2
Corrier, timber, hond, 4 ft.	____	2
Chain assembly, single leg, grob hook, ring, 20,000 lb.	____	1
Chest, ax, 37 15/16 in. x 13½ in. x 9 7/16 in., for 13 oxe	____	3
Chest, pioneer tools, 23½ in. x 17½ in. x 8¼ in.	____	1
Climbers set, tree and pole, w/strops and pads, adjustob	____	1
Croyon, marking, blue, 12 per box.	____	6
Croyon, marking, red, 12 per box.	____	6
Crowbar, pinch point, 59 to 62 in. long.	____	3
Cutter, bolt, rigid heod, 22 in. long.	____	3
Drill, mosonry, hond, star, 1 3/4 in., 36 in. long.	____	3
File, hand, crosscut, 8 in.	____	2
Frame, hond hocksow, odjustoble, 8 - 12 in. blode.	____	1
Grinding mochine, bench, hand operated, 6 in. diometer.	____	1
Grip, coble, jow, 5000 lb. lood, 0 to ½ in. wire rope.	____	2
Hommer, hond, blacksmith, double face, 8 lb.	____	4
Hommer, hond, nopping, double foce, 3 lb.	____	3
Hammer, hond, railrood trock maul, double foce, 10 lb.	____	2
Hommer, hond, stonemoson, 3 lb.	____	2
Hondle, odz, 34 in.	____	1
Hondle, cant hook ond peavy, 60 in. long.	____	2
Hondle, file, wood, 4½ in. long.	____	2
Hondle, hommer, wood, blacksmith, 16 in. long.	____	3
Hondle, hammer, wood, sledge, 36 in. long.	____	4

Components	Quantity
Handle, mattock pick, drifting pick, 36 in. long.	2
Handle, mattock pick, railroad or clay pick, 36 in.	8
Handle, shovel, wood, D, 27 in. long.	4
Handle, shovel, wood, long, 48 in. long.	6
Handle, single bit, ax, 36 in.	6
Jack, screw, hand, 12 ton.	1
Level, line, metal, 3 in. long.	1
Machete, rigid handle, 18 in. long.	4
Mallet, wood, 8 in. diameter face.	2
Marline, hemp, tarred, 220 ft. per lb., 160 lb. strength.	10 lb.
Mattock, pick handled, 5 lb.	2
Nail, common, wire, flat head, 8d, 2½ in. long.	50 lb.
Nail, common, wire, flat head, 10d, 3 in. long.	100 lb.
Nail, common, wire, flat head, 30d, 4½ in. long.	50 lb.
Nail, common, wire, flat head, 60d, 6 in. long.	100 lb.
Oiler, hand, 12 oz.	1
Peavy, 13 in. long, 54 in. handle	2
Pick, digging, drifting, handled, 5 lb.	2
Pick, digging, railroad or clay, handled, 7 lb.	14
Pliers, lineman's, 8 in.	6
Pliers, slip joint, w/cutter, 8 in.	2
Rope, manila, 13.3 ft. per lb., 2650 lb. strength.	31 lb.
Rope, manila, 6 ft. per lb., 5400 lb. strength.	33 lb.
Rope, manila, 3.71 ft. per lb., 9000 lb. strength.	81 lb.
Saw, crosscut, two man, 5 ft.	2
Shovel, hand, D-handle.	16
Shovel, hand, long handle.	16
Spoon, miner's, 56 in.	1
Strap, safety, industrial, leather, 70 in.	1
Tape, textile, general purpose, 3/4 in. wide.	540 yd.
Tool kit, crosscut saw reconditioning.	1

Components		Quantity
Trowel, brick.	____	2
Trowel, cement.	____	1
Twine, cotton, 35 lb. strength, 150 ft.	____	2
Wedge, timber, splitting, flored bit, 5 lb.	____	2
Wire, steel, corbon, 5 lb. reel.	____	2
Wrench, open end, odjustable, 8 in. long.	____	1
Wrench, open end, odjustable, 12 in. long.	____	2
Wrench, open end, odjustoble, 24 in. long.	____	1
Wrench, pipe, odjustoble, Stillson, 18 in. long.	____	2

Table 98. Maximum Bending Moments and Shear

Condition	Diagram	M max	V max
Supported both ends, load concentrated at center Simply supported		$\frac{FL}{4}$	$\frac{F}{2}$
Concentrated load, distance X from one Simply supported		$\frac{FXY}{L}$	$\frac{FY}{L}$ (Provided X is less than Y)
Uniformly distributed load Simply supported		$\frac{wL^2}{8}$	$\frac{wL}{2}$
Load evenly distributed over a distance X Simply supported		$R_1\ Y\frac{R_2}{2w}$	$\frac{wX}{2L}\ 2Z + X$
Cantilever, concentrated load at free end		FL	F

Section V. Rigging

110. CHARACTERISTICS OF KNOTS, see figure 183.

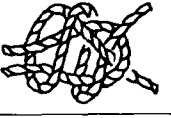
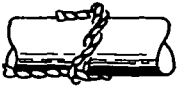
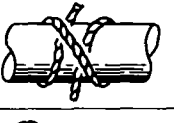
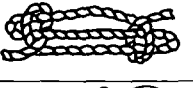
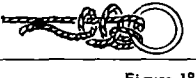
Name	Illustration	Use
Square		Join two ropes of same size. (Will not slip, but will draw tight under strain.) To end block lashing.
Double sheet bend		Join wet ropes, of unequal size, or rope to an eye. (Will not slip or draw tight under strain.)
Bowline		Form a loop. (Will not slip under strain and is easily untied.)
Timber hitch		Lifting or dragging heavy timbers. (Is more easily controlled if supplemented by half hitches.)
Clove hitch		Fasten rope to pipe, timber, or post. (It is used to start and finish all lashings and may be tied at any point in rope.)
Sheep shank		Shorten rope or take load off weak spot in rope.
Anchor knot		To fasten cable or rope to anchor.

Figure 183. Knots.

Table 99. Dimensions and Properties (Dressed Timber)

Nominal size	American standard	Area of section	$I \quad \frac{bh^3}{12}$	$S \quad \frac{bh^2}{6}$
In.	In.	In.^{2}	In.^{4}	In.^{3}
1 x 3	25/32 x 2 5/8	2.05	1 18	0.90
1 x 4	25 32 x 3 5/8	2.83	3.10	1.71
1 x 6	25/32 x 5 5/8	4.39	11.59	4 12
1 x 8	25/32 x 7 1/2	5 86	27.47	7.32
1 x 10	25/32 x 9 1/2	7.42	55 82	11.75
1 x 12	25/32 x 11 1/2	8 98	99.02	17.22
2 x 4	1 5/8 x 3 5/8	5.89	6.45	3.56
2 x 6	1 5/8 x 5 5/8	9.14	24.10	8.57
2 x 8	1 5/8 x 7 1/2	12 19	57.13	15.23
2 x 10	1 5/8 x 9 1/2	15.44	116 10	24.44
2 x 12	1 5/8 x 11 1/2	18 69	205 95	35.82
3 x 8	2 5/8 x 7 1/2	19.69	92.29	24.61
3 x 10	2 5/8 x 9 1/2	24.94	187 55	39 48
3 x 12	2 5/8 x 11 1/2	30.19	332.69	57.86
4 x 12	3 5/8 x 11 1/2	41.69	459.43	79 90
4 x 16	3 5/8 x 15 1/2	56 19	1,124.92	145 15
6 x 12	5 1/2 x 11 1/2	63.25	697.07	121 23
6 x 16	5 1/2 x 15 1/2	85.25	1,706 78	220 23
6 x 18	5 1/2 x 17 1/2	96.25	2,456.38	280.73
8 x 16	7 1/2 x 15 1/2	116.25	2,327.42	300.31
8 x 20	7 1/2 x 19 1/2	146.25	4,634.30	475.31
8 x 24	7 1/2 x 23 1/2	176.25	8,111 17	690.31

NOTE:

Lumber quantities are expressed in feet, board measure (fbm or BM). A board foot is the lumber in a rough-sawed board 1 foot long, 1 foot wide, and 1 inch thick. As an example, a 2" x 8" x 12' board has 12 x 2/3 x 2 or 16 fbm.

Table 100. Continued

Variety and grade of wood		Average unit weight[3], lb per cu ft	Allowable working stresses for military use[1], lb per sq in.				
Species and grade description	Stress grade[2]		Extreme fiber stress in bending[4]	Horizontal shear	Compression perpendicular to grain	Compression parallel to grain[5]	Modulus of elasticity
UNITED STATES SPECIES—Continued							
Structural	1,100f	–	1,650	150	400	1,500	–
Eastern hemlock	–	30	–	–	–	–	1,100,000
Select structural	1,100f	–	1,650	105	400	1,050	–
FOREIGN SPECIES							
Group I	–	45	–	–	–	–	1,600,000
Teak, sal, white siris, jarul, ook, ash, Philippine mahogany, lendia	–	–	1,800–2,700	200	360–500	1,680–2,000	–
Group II	–	35	–	–	–	–	1,250,000
Deodar, chir, paan gumhar, Narway (northern) pine	–	–	1,500–2,250	150	300–450	1,340–1,800	–
Group III	–	30	–	–	–	–	1,000,000
White deal, koil	–	–	1,340–2,000	100	260–390	1,110–1,500	–

[1]Reduce all stresses to 70 percent of tabular values for green wood and for design of parts of bridge structure continuously wet. Reduce all stress values to 75 percent of tabular values for design of structures carrying long-continued live load.

[2]Grade designations adopted by United States lumber industry for long-time use.

[3]At about 15 percent moisture content.

[4]Working stress in tensions same as for bending.

[5]Working stresses for compression parallel to grain apply to posts, columns, and struts, the unsupported length of which does not exceed 11 times the least dimension of cross section.

Table 100. Structural Timber Data

Variety and grade of wood		Average unit weight[3], lb per cu ft	Allowable working stresses for military use[1], lb per sq in.				
Species and grade description	Stress grade[2]		Extreme fiber stress in bending[4]	Horizontal shear	Compression perpendicular to grain	Compression parallel to grain[5]	Modulus of elasticity
UNITED STATES SPECIES							
Douglas fir	–	35	–	–	–	–	1,600,000
Dense select structural	1,800f	–	2,700	180	500	1,950	–
Select structural	1,600f	–	2,400	150	450	1,800	–
	1,400f	–	2,100	180	500	1,650	–
Yellow pine (long leaf, or dense short leaf)	–	40	–	–	–	–	1,600,000
Select structural	2,000f	–	3,000	150	500	2,200	–
Prime structural	1,800f	–	2,700	150	500	1,950	–
Merchantable structural; and structural square edge and sound	1,600f	–	2,400	150	500	1,800	–
No. 1 structural	1,400f	–	2,100	150	500	1,500	–
Larch	–	36	–	–	–	–	1,300,000
Select structural	1,800f	–	2,700	200	500	1,950	–
Structural	1,600f	–	2,400	150	470	1,800	–
Common structurol	1,200f	–	1,800	135	430	1,650	–
Redwood (structural)	–	30	–	–	–	–	1,200,000
Dense select all heart	1,400f	–	2,100	135	350	1,800	–
Select all heart	1,200f	–	1,800	120	350	1,650	–
Bulkhead and heart	1,000f	–	1,650	120	350	1,500	–
Southern cypress	–	32	–	–	–	–	1,200,000
Select structural	1,400f	–	2,100	180	400	1,800	–

Table 101. Breaking Strength of Wire Rope

Breaking strength in tons (6 by 19 wire rope)									
Diameter, in.	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Approximate weight per 100 ft, lbs. .	23	40	63	90	123	160	203	250	360
Material									
Wrought iron . . .	2.1	3.6	5.5	7.9	10.6	13.7	17.2	21.0	29.7
Traction steel . .	4.0	6.8	10.4	14.8	20.0	26.0	32.7*	40.6	56.6
Cose steel . . .	4.5	7.7	11.8	16.8	22.8	29.5	37.0	46.0	65.0
Mild plow steel .	5.0	8.5	13.1	18.7	25.4	33.0	41.5	51.0	72.5
Plow steel . . .	5.5	9.4	14.4	20.6	28.0	36.5	46.0	56.5	80.5
Improved plow steel	6.3	10.8	16.6	23.7	32.2	42.0	53.0	65.0	92.5

b = length of base

c = hypatenuse

C = circumference

V = volume

π = 3.1416

l = length of arc

k = length of chord

111. FIBER ROPES, WIRE ROPES, CHAINS, AND HOOKS

a. Dota. See tobles 101 through 104 for dota an ropes ond chains.

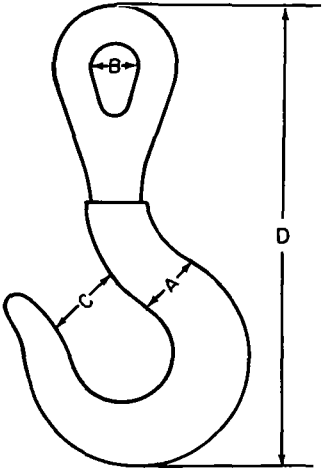
b. Properties of Hooks.

(1) Figure 184 shows the slip hook,

(2) Laods. Safe loads are given in toble 105.

112. MECHANICAL ADVANTAGES OF VARIOUS BLOCK ARRANGEMENTS

a. Blocks and Tockle. Figure 185 shows examples af typical tackle systems. In a simple tockle with 2 lines (fig. 185-1) leoving the lood the mechanical advontoge is 2. In a simple tockle with three lines (fig. 185-2) leaving the load, the mechanicol



SLIP HOOK

Figure 184. Type of hook

odvontoge is 3. In o simple tockle, using 2 double blocks (fig. 185-3), with 5 lines leoving the lood, the mechonicol odvontoge is 5. In o compound system with 5 lines (fig. 185-4) leoving the lood, ond the foll line of this tockle ottoched to o troveling block with 2 lines supporting it, the mechonicol odvontoge is 2 times 5, or 10. A more complicoted compound system (fig. 185-5) is mode up of two simple systems, eoch of which hos 4 lines supporting the lood. The troveling block of the first simple system is fostened to the foll line of the second simple system, ond the mechonicol odvontoge of this compound system is 4 times 4, or 16.

b. Choin Hoists.

(1) With o choin hoist, o lood con remoin stotionory without requiring ottention, ond the hoist con be operoted by one mon to roise loods of severol tons.

Table 102. Properties of Monilo and Sisal Rope

Nominal diameter in.	Circum-ference in.	lbs per ft	No. 1 monilo		Sisol	
			Breaking strength, tons	Safe load, tons (F.S. = 4)	Breaking strength, tons	Safe load, tons (F.S. = 4)
1/4	3/4	.020	0.27	0.07	0.22	0.06
3/8	1 1/8	.041	0.63	0.16	0.51	0.13
1/2	1 1/2	.075	1.32	0.33	1.06	0.26
5/8	2	.133	2.20	0.50	1.76	0.44
3/4	2 1/4	.167	2.70	0.67	2.16	0.54
7/8	2 3/4	.186	3.85	0.96	3.08	0.77
1	3	.270	4.50	1.12	3.60	0.90
1 1/8	3 1/2	.360	6.00	1.50	4.80	1.20
1 1/4	3 3/4	.418	6.72	1.69	5.40	1.35
1 1/2	4 1/2	.600	9.25	2.31	7.40	1.85
1 3/4	5 1/2	.895	13.25	3.31	10.60	2.65
2	6	1.08	15.50	3.87	12.40	3.10
2 1/2	7 1/2	1.35	23.25	5.81	18.60	4.65
3	9	2.42	32.00	8.00	25.60	6.40

NOTES: 1. Breaking strength and safe loads given are for new rope used under favorable conditions. As rope ages or deteriorates, progressively reduce safe loads to one-half of values given.

2. Safe working load may be computed, with safety factor of 4. When condition of material is doubtful, divide computation by 2.

$$T = D^2$$

where, T = safe working stress in tons
D = diameter in inches

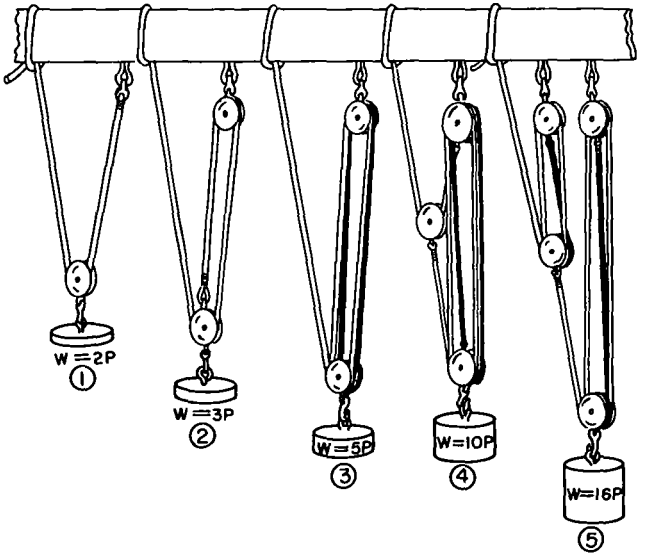


Figure 185. Mechanical advantage of various tackle riggings.

(2) *In figure 186 are* examples of two chain hoists.

Rules of thumb. Safe working load may be approximated by the following formulas which use a safety factor of about 4. Where age and condition of material are doubtful, or where human life or expensive equipment may be endangered, divide the computed safe working stress by 2.

T = safe working stress in tons.
D = diameter in inches. For chain, D is diameter of metal of one side of link.

Table 103. | Breaking Strength of 6 x 19 Standard Wire Hoisting Rope [1]

Diameter, in.[3]	Approximate weight, lbs	Breaking strength,[2] tons of 2,000 lbs.				
		Iron	Tractian steel	Mild plaw steel	Plaw steel	Improved plow steel
1/4	0.10	1.4	2.6	2.07	2.39	2.74
3/8	0.23	2.1	4.0	5.0	5.5	6.3
1/2	0.40	3.6	6.8	8.5	9.4	10.8
5/8	0.63	5.5	10.4	13.1	14.4	16.6
3/4	0.90	7.9	14.8	18.7	20.6	23.7
7/8	1.23	10.6	20.0	25.4	28.0	32.2
1	1.60	13.7	26.0	33.0	36.5	42.0
1-1/8	2.03	17.2	32.7	41.5	46.0	53.0
1-1/4	2.50	21.0	40.6	51.0	56.5	65.0
1-1/2	3.60	29.7	56.6	72.5	80.5	92.5

[1] 6 x 19 meons rope composed af 6 strands of 19 wires eoch. Strength af wire rope vories slightly with the strand construction and number of strands.

[2] The maximum ollowoble working load is the breoking strength divided by the appropriate factor of sofety as given in table 104.

[3] Safe working load. (See note 2 under table 102) $T = 8D^2$

Table 104. Wire Rope Safety Factors *

Type af service	Minimum safety factar
Track cables	3.2
Guys	3.5
Miscellaneous hoisting equipment	5.0
Haulage ropes	6.0
Derricks	6.0
Small electric and oir hoists	7.0
Slings	8.0

* Where age and condition of rope are daubtful, or where human life or expensive equipment moy be endangered by rope foilures, apply a safety factor of at least 8.

113. PICKET HOLDFAST

a. **Picket Holdfast, 1-1-1 Combination (fig. 187).**

b. **Picket Holdfast, 3-2-1 Combination (fig. 188).**

c. **Holding Power.** Sound wooden pickets 3 inches in diameter driven at least 3 feet into undisturbed earth and spaced 3 to 6 feet apart should stand the following pulls,

	Pounds
Single picket	700
1-1 picket holdfast combination	1,400
1-1-1 picket holdfast combination	1,800
2-1 picket holdfast combination	2,000
3-2-1 picket holdfast combination	4,000

For wet earth, holding power should be multiplied by the following factors.

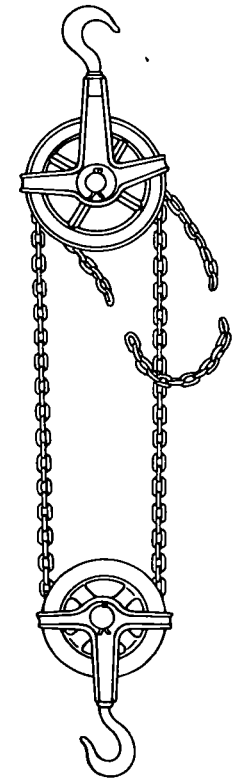
Clay and gravel	0.9
River clay and sand	0.5

Table 105. Safe Loads on Hooks

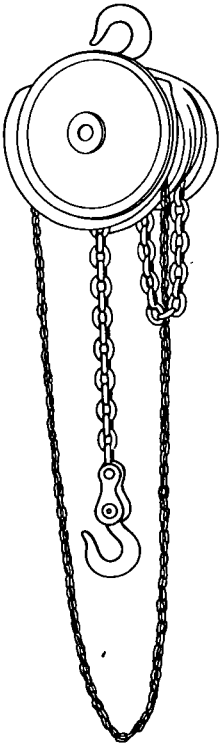
Diameter of metal A,* in.	Inside diameter of eye B, in.	Width of opening C, in.	Length of hook D, in.	Safe load on hook, lbs.
11/16	7/8	1-1/16	4-15/16	1,200
3/4	1	1-1/8	5-13/32	1,400
7/8	1-1/8	1-1/4	6-1/4	2,400
1	1-1/4	1-3/8	6-7/8	3,400
1-1/8	1-3/8	1-1/2	7-5/8	4,200
1-1/4	1-1/2	1-11/16	8-19/32	5,000
1-3/8	1-5/8	1-7/8	9-1/2	6,000
1-1/2	1-3/4	2-1/16	10-11/32	8,000
1-5/8	2	2-1/4	11-27/32	9,400
1-7/8	2-3/8	2-1/2	13-9/32	11,000
2-1/4	2-3/4	3	14-13/16	13,600
2-5/8	3-1/8	3-3/8	16-1/2	17,000
3	3-1/2	4	19-3/4	24,000

* For reference to A, B, C, or D, see figure 184.

NOTE: Formula for safe work load for hooks: $T = D^2$



(1) DIFFERENTIAL CHAIN-HOIST



(2) SPUR GEAR

Figure 186. Chain hoists.

114. DEADMAN

a. **Log Deadmon (fig. 189).**

b. **Steel Beam Deodman (fig. 190).**

c. **Holding Power of Deodmen in Ordinory Earth.**

(1) Log deodmon.

Legend: for figure 189 ond the formulos below:

T = tension (Breoking strength of rope)
MD = meon depth (you select)
SR = slope rotio (½, 1/3, ¼, etc.)
HD = horizontol distonce (see formulo in (2) below)
VD = verticol depth (Must be ot leost 1 ft. above meter toble)
HP = holding power (see toble 106)
BAr = beoring oreo requires (see formulo in (2) below)
EL = effective length (see formulo in (2) below)
WST = width, sloping trench (1 to 2 feet)
Tim D = timber diometer (you select)
Tim L = timber length (see formulo in (2) below)

(2) Formulos.

(a) $BAr = \frac{T}{HP}$ (in lbs)

(b) $EL = \frac{BAr}{Tim\ D}$

(c) $Tim\ L = EL + WST$

(d) $VD = MD + (\frac{Tim\ D}{2})$

(e) $HD = \frac{VD}{SR}$

(3) Problems.

Given:			Find:
T	=	1 in. wire rope I.P.S.	BAr
MD	=	7 ft.	EL
SR	=	¼	Tim L
HP	=	8,400 lb. (toble 106)	VD
WST	=	1½ ft.	HD

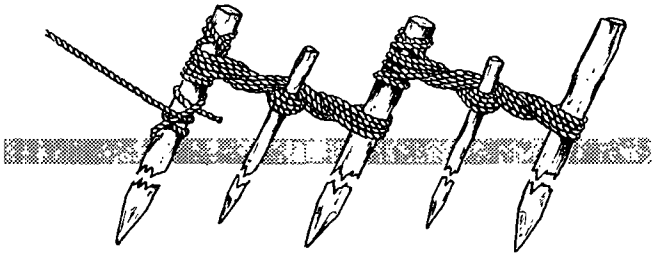


Figure 187. Picket holdfast, 1-1-1 combination.

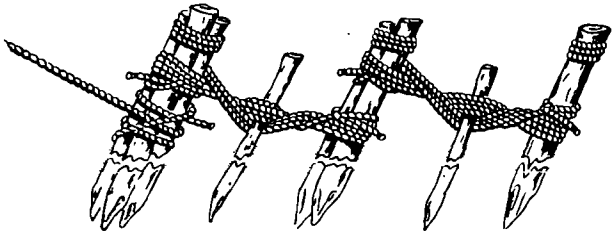


Figure 188. Picket holdfast, 3-2-1 combination.

Tim D = 2 ft.

Solution:

$$BAr = \frac{84,000}{8,400} = 10 \text{ sq. ft.}$$

$$EL = \frac{10}{2} = 5 \text{ ft.}$$

Tim L = 5 ft. + 1½ ft. = 6½ ft.

$$VD = 7 \text{ ft.} + \frac{2 \text{ ft.}}{2} = 8 \text{ ft.}$$

$$HD = \frac{8}{\frac{1}{4}} = 32 \text{ ft.}$$

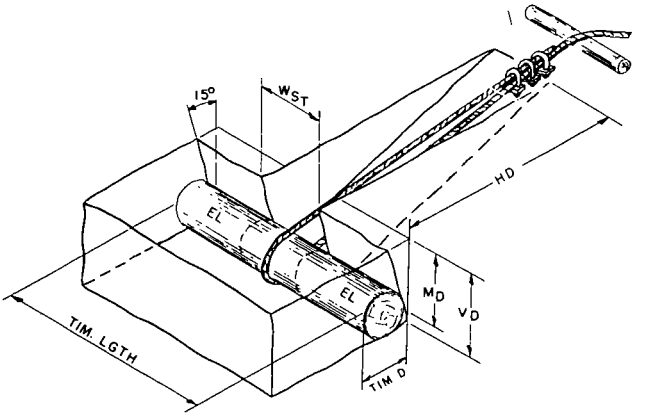


Figure 189. Log deadman.

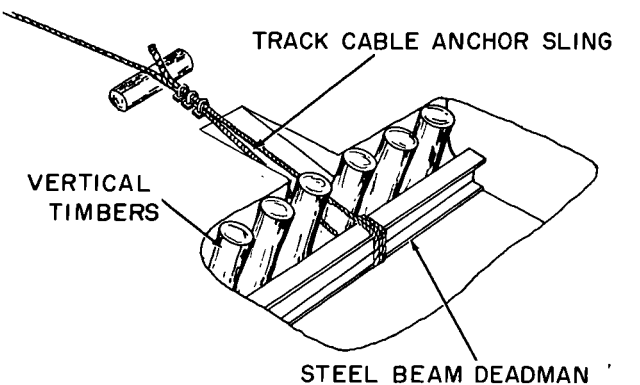


Figure 190. Steel beam deadman.

Table 106. Holding Power of Deadmen in Ordinary Earth

Mean depth of anchorage, ft	Safe resistance for inclination of pull (vertical or horizontal) of projected area of deadman, lbs per sq ft.				
	Vertical	1/1	1/2	1/3	1/4
3	600	950	1,300	1,450	1,500
4	1,050	1,750	2,200	2,600	2,700
5	1,700	2,800	3,600	4,000	4,100
6	2,400	3,800	5,100	5,800	6,000
7	3,200	5,100	7,000	8,000	8,400

Figure 191. Wire rope clips.

115. ATTACHMENTS

a. **Clips.** Clips are used in making up eyes in wire rope. The correct method of attaching clips is shown in figure 191. The base of each clips should bear against the line, or long rope, end, and the U-bolt should bear against the dead, or short, end. Space the clips at least six rope diameters apart, the number of clips equals three times the rope diameter (in inches) plus one. If this calculation results in a fraction, use the next larger whole number. For example, on a ¾-inch rope--

No. of clips = 3 D + 1 . (Minimum of 3 clips)
= (3 x ¾) + 1
= 3¼, or 4
Spacing of clips = 6 D

b. **Clamps.** Figure 192 illustrates how to apply a wire rope clamp. Slip the two end collars of the clamp on the rope, facing each other. Bend the rope, bringing the free end back along the long end. Slip one end collar of the clamp over both parts of the rope. Place the two side pieces of the clamp over both parts of the rope so that the free end of the rope is even with the ends of the two side pieces. Screw the collars on the side pieces, using a wrench to force a snug fit.

c. **Wedge Socket.** This fitting is shown in figure 193. It is used when the fitting must be changed at frequent intervals. This socket has two parts, the socket proper with a tapered opening for the wire rope and a small wedge to go into this socket. Remove the wedge and insert a loop of the wire rope through the tapered opening

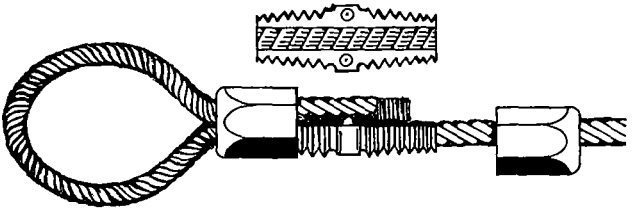
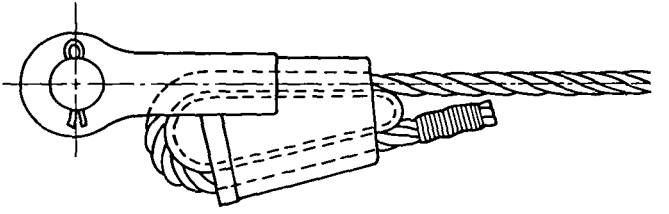


Figure 192. Wire rope clamp.



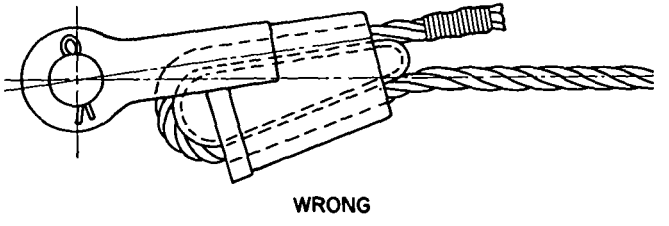


Figure 193. Wedge socket and fitting.

from the bottom of the socket up. Place the wedge through the loop and pull the ends of the wire rope back through the tapered opening until the wedge forces the wire rope against the sides of the wedge socket. The loop of wire rope must be inserted in the wedge socket so that the long part of the wire rope will form o nearly direct line to the clevis pin of the fitting. If properly mounted, o wedge socket will tighten when o strain is put on the wire rope.

116. SAFE CAPACITY OF SPRUCE TIMBER AS A GIN POLE

See toble 107 for these capacities. Weight of timber is 40 pounds per cubic foot.

Table 107. Safe Capacity of Spruce Timbers as Gin Poles in Normal Operations

Size of timber, in.	Safe capacity for given length of timber, lbs					
	20 ft (6 m)	25 ft (7.5 m)	30 ft (9 m)	40 ft (12 m)	50 ft (15 m)	60 ft (18 m)
6 dia	5,000	3,000	2,000	----------	----------	----------
8 dio	----------	11,000	8,000	5,000	3,000	----------
10 dia	31,000	24,000	16,000	9,000	6,000	----------
12 dia	----------	----------	31,000	19,000	12,000	9,000
6 x 6	6,000	4,000	3,000	----------	----------	----------
8 x 8	----------	14,000	10,000	6,000	4,000	----------
10 x 10	40,000	30,000	20,000	12,000	8,000	----------
12 x 12	----------	----------	40,000	24,000	16,000	12,000

NOTE: Safe capacity of each leg of sheors or tripod is seven-eights of the value given for a gin pole.

117. SLINGS

a. **Single Slings.** See figure 195 for components of a single sling.

(1) A bosket hitch has o single sling passed under the load ond both ends hooked over the hoisting hook (fig. 194A).

(2) Single slings with two hooks are sometimes used for lifting stone (fig. 194B).

(3) The double anchor hitch is used sometimes for hoisting cylindricol objects (fig. 194C).

b. **Endless Slings.**

(1) The anchor, or choker, hitch is o common method of using on endless sling by casting the sling under the lood and inserting one loop through the other and over the hoisting hook (fig. 194D).

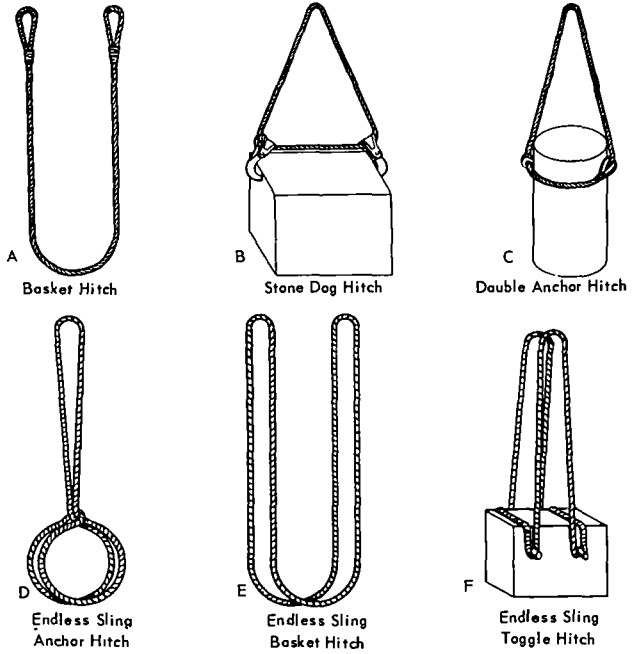


Figure 194. Hitches.

(2) For a basket hitch, the endless sling is passed around the object and both remaining loops are slipped on the hook (fig. 194E).

(3) The *toggle hitch* is a modification of the basket hitch and is used only for special applications (fig. 194F).

118. SLING LOAD FORMULA

a. Stress. The stress or tension in each leg of a sling depends on the number of legs, the angle of the sling leg, and the total load.

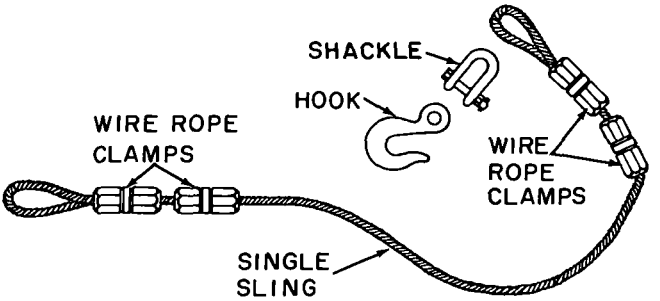


Figure 195. Single sling components.

b. Formula. (See fig. 196).

$$T = \frac{W}{N} \times \frac{L}{V}$$

where T = tension, in pounds
N = number of legs
W = weight, in pounds
V = vertical distance, in feet
L = length of leg, in feet.

c. Problem. Is it safe to use a ¾-inch cordage rope sling to lift a 2,000-pound load with a 4-leg sling which has vertical distances of 6 feet and length of leg of 12 feet?

$$T = \frac{W}{N} \times \frac{L}{V}$$

$$T = \frac{2{,}000}{4} \times \frac{12}{6} = 1{,}000 \text{ pounds}$$

The tension on each leg will be 1,000 pounds. The safe working capacity of ¾-inch cordage rope is: $T = D^2 (3/4)^2 = 9/16 = .5625$ ton = 1125 pounds. Sling is safe.

119. SLING LOAD CHART

See figure 197.

120. SHEARS

a. Materials. This device is used to erect heavy machinery and bulky objects. Figure 198 shows its construction. It must be guyed to hold its position. It is adapted to work at an inclination from the vertical. Each sheer leg should not be

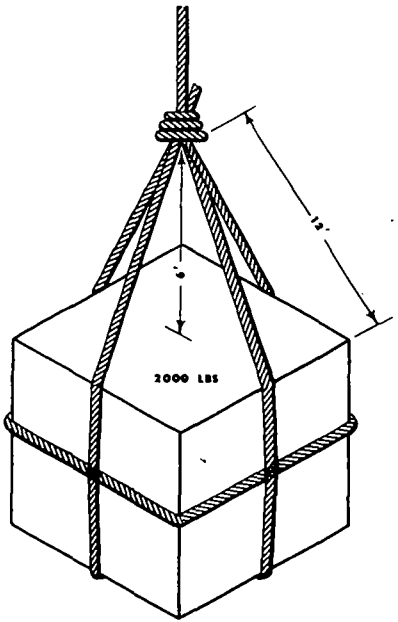
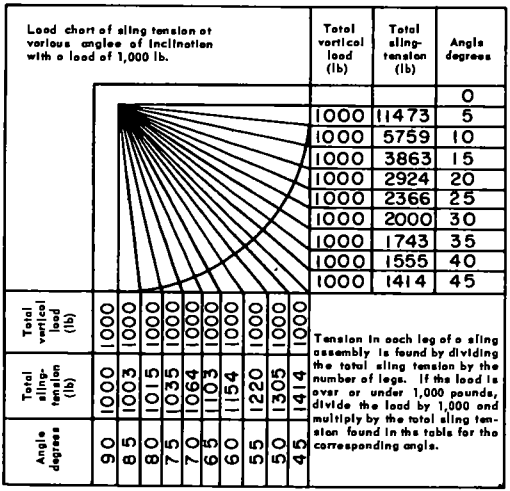


Figure 196. Sling stresses.


Load chart of sling tension at various anglee of inclination with a load of 1,000 lb.
Total vertical load (lb)
Total sling-tension (lb)
Angle degrees
1000 11473 0
1000 5759 5
1000 3863 10
1000 2924 15
1000 2366 20
1000 2000 25
1000 1743 30
1000 1555 35
1000 1414 40
1000 1414 45
Total vertical load (lb)
1000 1000 1000 1000 1000 1000 1000 1000 1000 1000
Total sling-tension (lb)
1000 1003 1015 1035 1064 1103 1154 1220 1305 1414
Angle degrees
90 85 80 75 70 65 60 55 50 45
Tension in each leg of a sling assembly is found by dividing the total sling tension by the number of legs. If the load is over or under 1,000 pounds, divide the load by 1,000 and multiply by the total sling tension found in the table for the corresponding angle.

The chart illustrates the variation of tension on one sling leg when applied to a constant 1000-pound load at various angles.

Example

Problem: 100,000 pounds weight is to be lifted by a four-leg sling assembly with each leg lifting at an angle of 45 degrees. What will be the tension on one leg:

Procedure: From the chart the total sling tension on one leg at 45 degrees for 1000 pounds is 1414 pounds.

Total tension for 100,000 pounds = 141,400 pounds.

Tension on each leg = $\frac{141400}{4}$ = 35,350 pounds.

If all legs lifted vertically, the tension on each leg = $\frac{100000}{4}$ = 25,000 pounds.

Figure 197. Sling load chart.

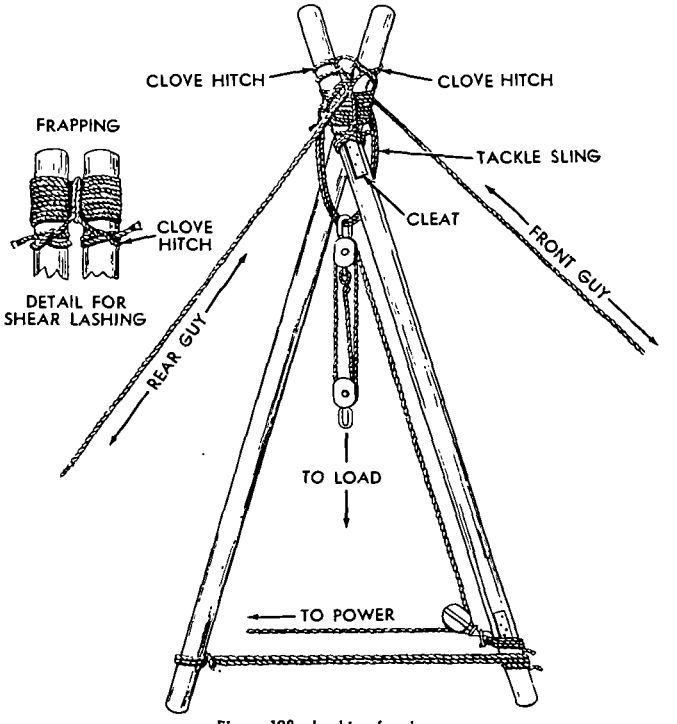


Figure 198. Lashing for shears.

longer than 40 times its minimum thickness, although the ratio may be up to 60 for light loads.

b. Erection. Holes should be dug at the points where the legs are to stand. On hard surface, the legs should be level and lashed to prevent spreading.

121. GIN POLE

a. Description. A gin pole is an upright spar, guyed at the top to hold it in a vertical or near-vertical position, and equipped with suitable hoisting tackle. It is easily rigged, moved, and operated.

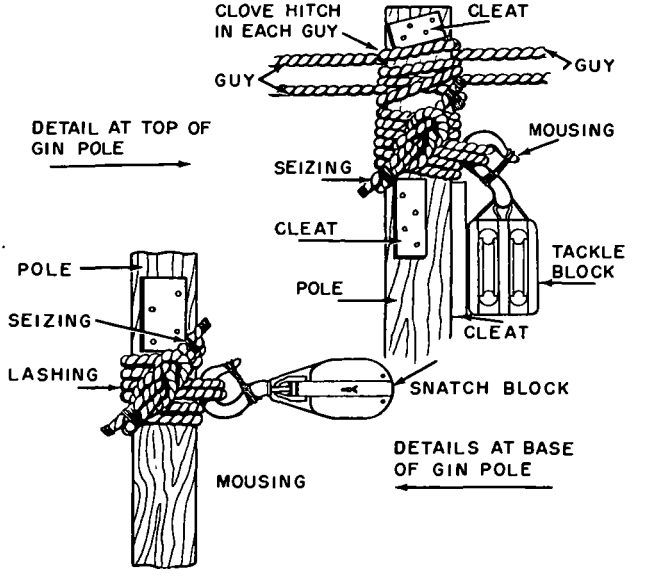


Figure 199. Lashings for a gin pole.

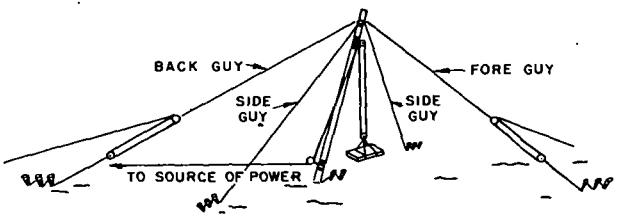


Figure 200. *Gin pole ready for operation.*

b. **Erecting.** A gin pole 30 or 40 feet long may be raised easily by hand, but longer poles must be raised by supplementary rigging or power equipment. Ten or twelve men are required to raise a gin pole. The lashings are illustrated in figure 199, while figure 200 shows the gin pole in position for operation. The maximum allowable length is 60 times the minimum diameter. Guys are 3 or 4 times the pole length.

122. BOOM DERRICK

a. **Rigging.** Booms are used on gin poles to lift loads at a distance from the base of the pole. The boom is two-thirds the length of the gin pole. For heavy loads, lower butt of boom to ground, raise it for lighter loads. It must not bear against the upper two-thirds of the pole.

b. **Operation.** Raise the boom into position when the rigging is finished. In operation, it is a convenient means for loading and unloading trucks and flatcars, and on docks or piers. Figure 201 shows the boom derrick in position for operation.

123. GUY LINE TENSION FOR SHEARS, GIN POLES, AND BOOM DERRICKS

The most stress on a guy line occurs when a straight line through the load and pole passes through the guy line. Because the pole moves around, this can happen at any time. To compute the tension, use the formula shown below.

$$t = \frac{wd}{y}$$

where t = tension in guy line.
w = weight of load + ½ weight of pole.
d = drift
y = perpendicular distance from rear guy line to base of pole.

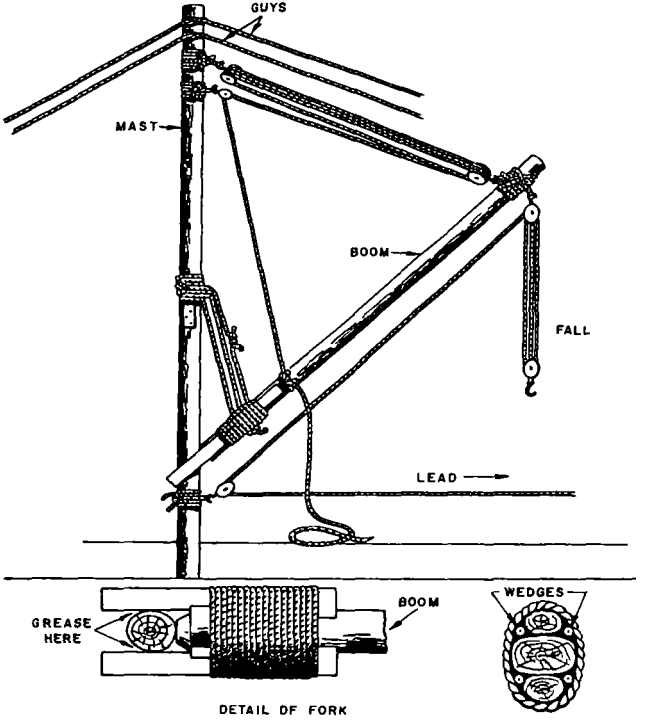


Figure 201. Boom derrick.

Figure 202 shows an illustration of the principles of this computation.

Problem:

Load	=	2,500
Weight of pole	=	800 pounds
Drift	=	10 feet
y-distance	=	20 feet

Therefore, $t = \frac{2,900 \times 10}{20} = 1,450$ lbs

TENSION, $t = \frac{wd}{y}$

WHERE: d = DRIFT
y = PERPENDICULAR DISTANCE FROM BASE OF POLE TO REAR GUYLINE
w = WEIGHT OF LOAD + ½ WEIGHT OF POLE

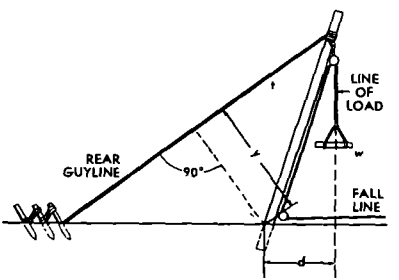


Figure 202. Computing stresses in single guylines

124. TRAMWAYS AND CABLEWAYS

a. **Tramways.** Tramways move loads in a horizontal direction. They are usually multiple span but can be single span.

b. **Cableways.** Cableways are always single span, but they differ from single-span tramways in that there must be a means of vertical load displacement as well as horizontal.

c. **Highline.** The highline is a trolley line passing through a snatch block at each support (fig. 203). It is the type most commonly erected at the plateau level.

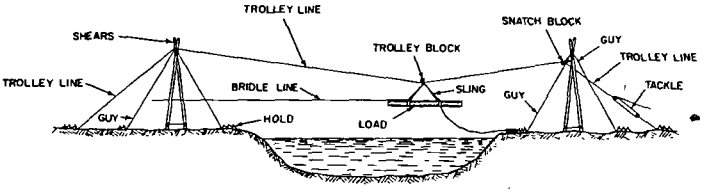


Figure 203 High line.

d. **Sag.** The sag in track cable when loaded should be not less than 5 percent of the span.

e. **Formula for Safeload of Highline.**

$$SL = \frac{BS\ (lbs)}{5 \times SF} - \frac{DL\ (lbs)}{2}$$

Problem:

Span is 400 feet
Track line is ¾-inch manila rope
Haul line is ½-inch manila rope
Safety factor is 4.0
Track cable sag is 5 percent.

Solution:

B S (breaking strength) for ¾-inch manila rope = 5,400 pounds

W (¾-inch rope) = 66.8 pounds/400 feet
Table 102 = 66.8 pounds/400 feet
W (½-inch rope) = 60 pounds/800 feet
Table 102 = 60 pounds/800 feet

Therefore,

$$SL = \frac{5,400}{5 \times 4.0} - \frac{66.8}{2}$$

$$SL = 270 - 33.4$$

$$SL = 236.6 \text{ pounds}$$

For the payload, use the formula

P L = S L – (½ W of haul rope + W of traveller + W of carrier)

For this problem, this would mean:

P L = 236.6 – (30 plus the weights of traveller and carrier).

NOTE: For information on suspension bridge, see Bridging.

Section VI. Signal Data

125. CODE AND ALPHABET

a. Morse Code.

A . –	J . – – –	S . . .	2 . . – – –
B – . . .	K – . –	T –	3 . . . – –
C – . – .	L . – . .	U . . –	4 . . . . –
D – . .	M – –	V . . . –	5 . . . . .
E .	N – .	W . – –	6 – . . . .
F . . – .	O – – –	X – . . –	7 – – . . .
G – – .	P . – – .	Y – . – –	8 – – – – .
H	Q – – . –	Z – – . .	9 – – – – .
I . .	R . – .	1 . – – – –	0 – – – – –

b. Phonetic Alphabet.

(International Civil Aviation Organization)

[Reference AR 105-30, AR 105-31 and ACP 125(B)] Speak only the word representing the letter, as LIMA, ZULU. Do not say L as in LIMA, or L for LIMA.

A	ALFA	G	GOLF	L	LIMA	Q	QUEBEC	V	VICTOR
B	BRAVO	H	HOTEL	M	MIKE	R	ROMEO	W	WHISKEY
C	CHARLIE	I	INDIA	N	NOVEMBER	S	SIERRA	X	X-RAY
D	DELTA	J	JULIET	O	OSCAR	T	TANGO	Y	YANKEE
E	ECHO	K	KILO	P	PAPA	U	UNIFORM	Z	ZULU
F	FOXTROT								
0	ZERO	2	TOO	4	FO-WER	6	SIX	8	ATE
1	WUN	3	THUH-REE	5	FI-YIV	7	SEVEN	9	NINER

126. RADIO TELEPHONE PROCEDURE

a. **General Instructions.**

(1) Write or plan message before transmitting.

(2) Listen before transmitting.

(3) Speak clearly and slowly.

(4) Keep all transmissions as brief as possible.

(5) Use the phonetic alphabet as directed in paragraph 125.

b. **Procedure.**

(1) Station identification. Stations are identified by tactical call signs obtained from unit SOI. EXAMPLES: X79: RED 5.

(2) Time. The originator's time of any message is always transmitted digit by digit. EXAMPLE: Time 2300 spoken as TIME TWO THREE ZERO ZERO.

(3) Operator's indorsement. Put on the message (incoming or outgoing) by the operator.

OUTGOING		INCOMING
CALL SIGN	FREQUENCY	CALL / FREQ / OPER / TIME OF SIGN / INIT / RECEIPT
OPERATOR INITIALS	TIME OF TRANSMISSION	

c. **Component Parts of a Message.**

(1) Each message will always contain three parts. HEADING, TEXT, AND ENDING.

(2) The HEADING will always include the call:

EXAMPLE: (Full call; communications conditions good)

CAGEY SIX - THIS IS - CAGEY TWO

(a) CAGEY SIX, the coll sign of the statian called.

(b) THIS IS, a praword thot may be faund in every tronsmission.

(c) CAGEY TWO, the call sign af the calling statian. The call moy be abbreviated after the initiol contact hos been mode by omitting the coll sign af the called stotion in each successive reply:

EXAMPLE: (Abbreviated coll) THIS IS CAGEY SIX Other procedure items which may be faund in the HEADING in the follawing correct order are:

CALL

MESSAGE FOLLOWS

RELAY TO, READ BACK, DO NOT ANSWER

PRECEDENCE

TIME

FROM (FOLLOWED BY CALL SIGN)

TO (FOLLOWED BY CALL SIGN)

INFO (FOLLOWED BY CALL SIGN IF USED)

GROUPS (FOLLOWED BY NUMBER OF GROUPS IN MESSAGE TEXT-IF COUNTED)

(3) The TEXT may consist af plain longuoge, code, or cipher graups.

(4) The ENDING may include messoge authentication and must include either one af twa terminoting prawards, OVER or OUT but never both in the same transmission.

EXAMPLE: RED-EXEMPT RED TWO · THIS IS·RED FOUR-MESSAGE FOLLOWS - RED ONE · RELAY TO RED SIX - PRIORITY - TIME 131642Z - FROM - RED FOUR · TO · RED SIX - INFO - RED ONE - GROUPS NINER· BREAK - FIVE ENEMY TANKS REPORTED IN WOODS TO RIGHT FLANK· BREAK - AUTHENTICATION IS DELTA DELTA · OVER.

d. Authenticatian. Station authenticatian is tronsmitted as follows:

(1) The challenge is transmitted after the call-up, preceded by the phrose WHAT IS AUTHENTICATION OF

EXAMPLE: WARP, THIS IS SHADE - WHAT IS AUTHENTICATION OF GOLF SIERRA-OVER.

(2) The reply is similarly transmitted, preceded by the phrose AUTHENTICATION IS It may be followed by a counterchallenge.
EXAMPLE: SHADE, THIS IS WARP-AUTHENTICATION IS LIMA LIMA-WHAT IS AUTHENTICATION OF HOTEL PAPA · OVER.

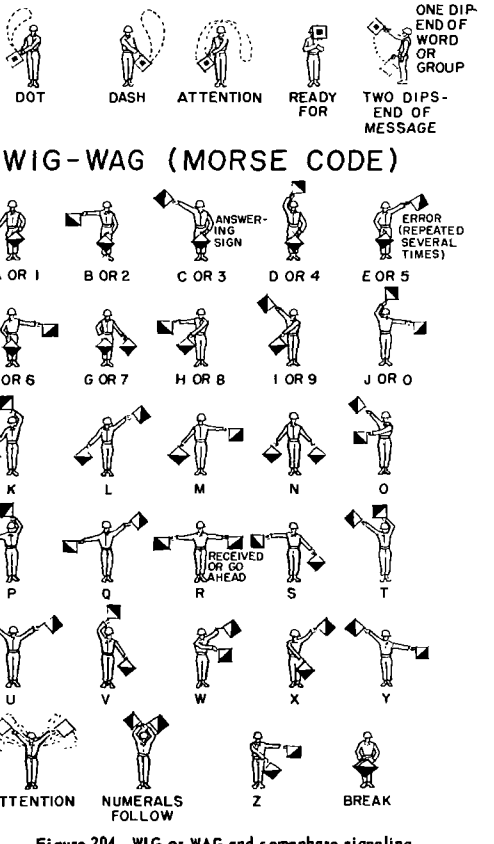


Figure 204. WIG or WAG and semaphore signaling.

ANSWER: THIS IS SHADE - AUTHENTICATION IS DELTA - OVER.

127. SIGNAL FLAGS

See figure 204 for illustrations of these signals.

128. PANEL CODE

For panel codes, numerals, indicators, and special signs, see figures 205 and 206.

129. GROUND-AIR EMERGENCY CODE

The following symbols may be made by using strips of fabric or parachute, pieces of wood, stones, or by tracking in the snow. Provide as much color contrast as possible between symbols and background. If possible, symbols should be 8 feet or more in length and 10 feet apart. In addition, use radio, flares, smoke, or other means to attract attention.

Require doctor, serious injuries	I
Require medical supplies	II
Unable to proceed	X
Require food and water	F
Require firearms and ammunition	⩔
Require map and compass	▭
Require signal lamp with battery and radio	⁞
Indicate direction to proceed	K
Am proceeding in this direction	↑
Will attempt takeoff	I⟩
Aircraft seriously damaged	L⅂
Probably safe to land here	△
Require fuel and oil	L
All well	LL

No	N
Yes	Y
Nat understaad	JL
Require engineer (mechanic)	W

NOTE: Elements shauld be spaced 10 feet apart, whenever passible.

Sectian VII. Miscellaneous

130. CHARACTERISTICS OF INFANTRY WEAPON

See table 108 far a chart an infantry weapans.

131. COMPUTATION OF MANHOURS

A standard guide far the camputatian af man-haurs, plataan haurs, and sa farth, far engineer units is suggested as fallaws:

a. Manpawer. Far a cambat engineer battalian (divisian), far example, use manpawer as fallaws:

(1) 10 men per squad.
(2) 30 men per plataan.
(3) 80 men per campany.
(4) 650 men per battalian.

b. Man-haurs. Use 10 man-haurs per day per man. Increase the time 50 percent far night wark.

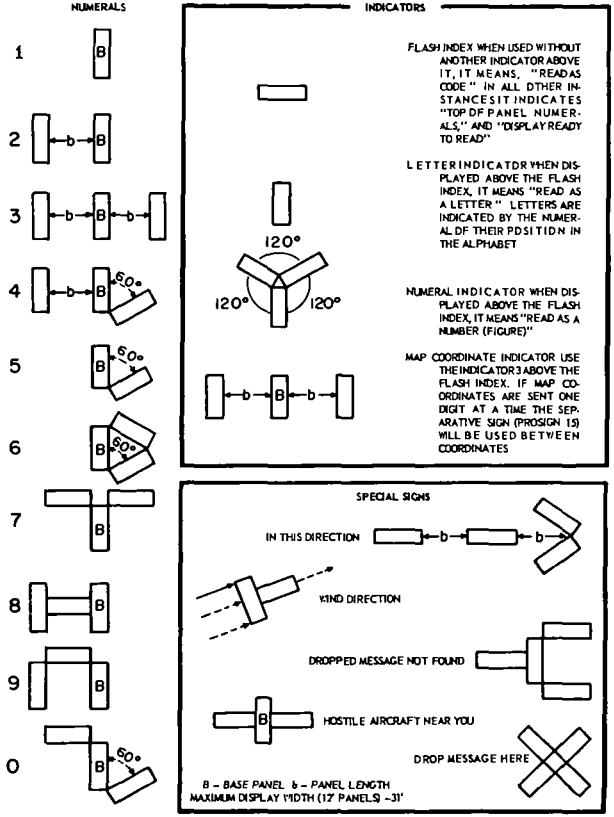

NUMERALS
1
2
3
4
5
6
7
8
9
0
B
b
60°
INDICATORS
FLASH INDEX WHEN USED WITHOUT ANOTHER INDICATOR ABOVE IT, IT MEANS, "READ AS CODE" IN ALL OTHER INSTANCES IT INDICATES "TOP OF PANEL NUMERALS," AND "DISPLAY READY TO READ"
LETTER INDICATOR WHEN DISPLAYED ABOVE THE FLASH INDEX, IT MEANS "READ AS A LETTER" LETTERS ARE INDICATED BY THE NUMERAL OF THEIR POSITION IN THE ALPHABET
120°
NUMERAL INDICATOR WHEN DISPLAYED ABOVE THE FLASH INDEX, IT MEANS "READ AS A NUMBER (FIGURE)"
MAP COORDINATE INDICATOR USE THE INDICATOR 3 ABOVE THE FLASH INDEX. IF MAP COORDINATES ARE SENT ONE DIGIT AT A TIME THE SEPARATIVE SIGN (PROSIGN 15) WILL BE USED BETWEEN COORDINATES
SPECIAL SIGNS
IN THIS DIRECTION
KIND DIRECTION
DROPPED MESSAGE NOT FOUND
HOSTILE AIRCRAFT NEAR YOU
DROP MESSAGE HERE
B – BASE PANEL b – PANEL LENGTH
MAXIMUM DISPLAY WIDTH (17 PANELS) –31'

Figure 205. Numerals and Indicators.

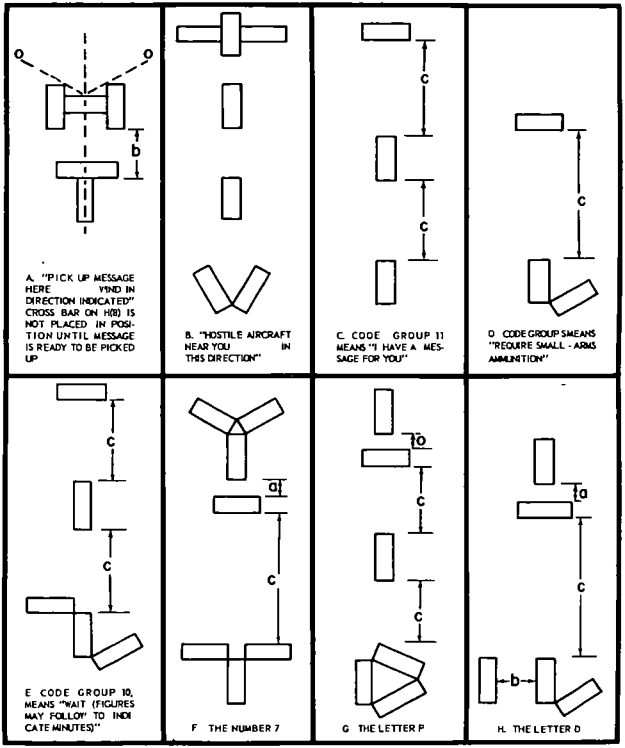

b
A. "PICK UP MESSAGE HERE WIND IN DIRECTION INDICATED" CROSS BAR ON H(B) IS NOT PLACED IN POSITION UNTIL MESSAGE IS READY TO BE PICKED UP
B. "HOSTILE AIRCRAFT NEAR YOU IN THIS DIRECTION"
c
c
C. CODE GROUP 11 MEANS "I HAVE A MESSAGE FOR YOU"
c
D CODE GROUP SMEANS "REQUIRE SMALL - ARMS AMMUNITION"
c
c
E CODE GROUP 10, MEANS "WAIT (FIGURES MAY FOLLOW TO INDICATE MINUTES)"
a
c
F THE NUMBER 7
a
c
c
G THE LETTER P
a
c
b
H. THE LETTER D
NORMAL SPACINGS:
a-½ PANEL LENGTH
b-1 PANEL LENGTH
c-1 TO 3 PANEL LENGTHS

Figure 206. Panel code and messages.

Table 108. Characteristics of Infantry Weapons

Weapons	Unloaded weight (approximate), lbs	Type of feed	*Cyclic (C) or maximum rate (M) of fire, rds per min	*Sustained rate of fire, rds per min	*Maximum effective rate of fire rds per min	*Maximum range (nearest 25)		*Maximum effective range (nearest 25)		Appx effective bursting area, Meters	Remarks
						Yards	Meters	Yards	Meters		
Hand Grenades M26A1	1					50	50			15	
Hand Grenades M15	2					25	25			15	
Pistol, Automatic Cal .45, M1911A1	2½	7 rd magazine	35–42	10	21–28(M)	1600	1475	50	50		
Submachinegun, Cal .45, M3A1	9	30 rd magazine	450(C)	40–60	40–60	1700	1550	100	100		To be replaced by M–14 rifle.
US Carbine, Cal 30, M2	5½	30 rd magazine	750–775(C)	40–60	40–60	2200	2025	275	250		To be replaced by M–14 rifle.
Sniperscope, Infrared Set NR 1,20,000 Volts	32	30 rd magazine	750–775(C)	40–60	20–30	2200	2025	125	125		To be replaced by M–14 rifle.
US Rifle, Cal 7.62MM, M14	8½	20 rd magazine	700–750(C) 40–60(M) Semiautomatic 120–150(M) Automatic	8–10	20–30 Semiautomatic 40–60 Automatic	3500	3200	500	450		Full automatic capability requires installation of selector lever. Sustained rate based on limited tests.
US Rifle, Cal .30M1	9½	8 rd clip	32–40(M)	8–10	16–24	3500	3200	500	450		To be replaced by M–14 rifle.
US Rifle, Cal .30M1C	12	8 rd clip	32–40(M)	8–10	16–24	3500	3200	800–1000	725–925		M81, M82, or M84 telescopes may be used.
US Rifle, Cal .30 M1, with Rifle Grenade Launcher, M7A3, Heat Rifle Grenade, M31 & Sight M15	10½	Manual	4(M)	4	2	300	275	125	125		Complete round weighs approx 1½ lbs.

Table 108. Continued

Weapon	*Unloaded* weight (Approximate) lbs	Type of feed	*Cyclic (C) or maximum rate (M) of fire rds per min	*Sustained rate of fire, rds per min	*Maximum effective rate of fire, rds per min	*Maximum range (nearest 25)		*Maximum effective range (nearest 25)		Appx effective bursting area, Meters	Remarks
						Yards	Meters	Yards	Meters		
Machinegun, Cal .50, HB, M2	126	belt metallic link	500(C)	40	100	7400	6800	800 AAA target 2000 ground target	725 AAA target 1825 ground target		
3–5-IN Rocket Launcher, M20A1B1	13	Breech loading by hand	12–18(M)	4	8–10	950	900	200 moving target 300 *stationary* target	175 moving target 275 *stationary* target	10x20	Complete round weighs approx 8½ lbs. Sustained rate *based on estimate.*
Portable Flamethrower, M2A1–7	40½	Fuel propelled by gas under pressure	Continuous discharge 6–9 sec	Continuous discharge 6–9 sec	Continuous discharge 6–9 sec	25 Unthickened 50 Thickened fuel	25 50	25 Unthickened 50 Thickened fuel	25 50		Contains 4½–4¾ gals of fuel weighing 25 to 29 lbs
81MM Mortar, M29 with Mount, M23A3	Barrel –28 Bipod 40 Baseplate 25	Muzzle loading by hand	24(M) for 1 min with charge 8	2 with charge 8	2	4000	3675	4000	3675	30 x 20(A)	Ammunition weights 7–12 lbs (A) maximum rate and sustained rate with charges 1–7 to be determined
4–2-in Mortar, M30 with Mount, M24A1 (Artillery Weapon)	640	Muzzle loading by hand	15–20(M)	1	1	6000	5500	6000	5500	45 x 15(A)	Ammunition weighs 25–28 lbs. (A)
106MM Rifle, M40A1 with Spotting Rifle Cal 50, M8 (On M38A1 ¼ Ton Truck)	483(B) (including spotting rifle)	Breech loading by hand spotting rifle-10 rd magazine	1 per 6 sec with not more than 5 rds before allowing rifle to cool	1	5–6	8400 (A)	7700 (A)	1200 moving target 1500 Stationary target	1100 moving target 1375	15(A)	Maximum effective range determined by spotting rifle

NOTES: (A) *Depending upon type of ammunition used.* (B) *Not including vehicle.*

Tabfe 108 Continued

Weapon	Unloaded weight (Approximate) fbe	Type af feed	*Cyclic (C) or maximum rate (M) af fire rde per min	*Sue-tained rate of fire, rde per min	*Meximum effective rate af fire, rde per min	*Maximum range (nearest 25)		*Maximum effective range (nearest 25)		Appx effective burst-ing area, Metere	Remarks
						Yarde	Metere	Yarde	Metere		
US Rifle, Cal 7.62MM, M15	13½	20 rd magazine	700–750(C) 40–60(M) Semiautomatic 120–150(M) Automatic	15–20	20–30 Semiauta-matic 40–60 Automatic (2 to 3rd bursts) 120–150 (20 rd bursts)	3500	3200	500	450		Sustained rate based on limited teste.
Browning Automatic Rifle, Cal .30, M1918A2	19½	20 rd magazine	350(C) Slow Rate 550(C) Fast Rate 120–150(M)	40–60	40–60 (2 to 3 rd bursts) 120–150 (20 rd bursts)	3000–3500	2750–3200	500	450		To be replaced by M–15 rifle.
Machinegun, Cal 7.62MM, M60	Gun 23 Tripod 25	belt metallic link	600(C)	100	200	4100	3750	1200	1100		Maximum effective range limited by gunners ability to see and adjust on target. May be fired from bipod mount.
Browning Machinegun, Cal 30, M1919A6	33	belt metallic link	600–675(C)	75	150	3500	3200	1200	1100		Maximum effective range limited by gunnere ability to see and adjust on target. May be fired from triped mount. LMG to be replaced by M60.

132. CONVERSION OF KNOTS, MILES PER HOUR, AND FEET PER SECOND

See figure 207 for a chart showing these conversions.

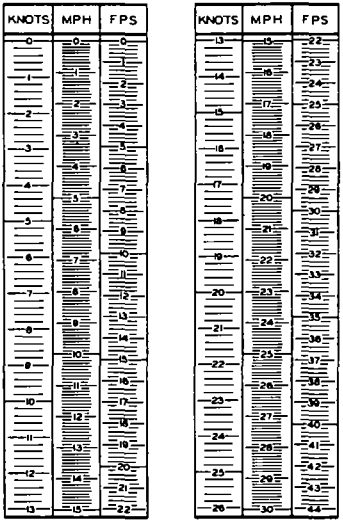


Figure 207. Conversion chart for knots, mph, and fps.

133. CONVERSION FACTORS

a. Weights and Measures. See table 109 for conversion factors on weights and measurements.

b. Linear Measure. See table 110 for these conversions.

c. Time-Distance. See table 111 for time-distance conversion.

Table 109. United States, British, and Metric Units
All weights ore Avoirdupois unless otherwise specified

Multiply	By	To obtain
acres	43,560	sq ft
acres	4047	sq meters
board feet	144	cu in
bushels (US)	1.244	cu ft
bushels (US)	32	qts (dry)
centimeters	.03281	ft
centimeters	.3937	in
cubic centimeters	.06102	cu in
cubic centimeters	.001	liters
cubic feet	1728	cu in
cubic feet	.02832	cu meters
cubic feet	.03704	cu yds
cubic feet	7.481	gals (US)
cubic feet	28.32	liters
cubic feet	.025	tons (ship)
cubic feet per minute	.1247	gals per sec
cubic feet per second	646,315	gals per day
cubic inches	16.39	cu cm
cubic inches	.0005787	cu ft
cubic inches	.004329	gals (US)
cubic inches	.01639	liters
cubic meters	35.31	cu ft
cubic meters	1.308	cu yds
cubic yards	27	cu ft
cubic yards	.7646	cu meters
degrees	60	min (circular)
fathoms	6	ft
feet	30.48	cm
feet	.1667	fathams
feet	.3048	meters
feet of water	62.43	lbs per sq ft
feet per minute	.01136	mil per hr
feet per second	.5921	knots
feet per second	.6818	mil per hr
gallons (British)	.1605	cu ft
gallons (British)	1.201	gals (US)
gallons (US)	3785	cu cm

Table 109. Continued

Multiply	By	To obtain
gallans (US)	.1337	cu ft
gollans (US)	231	cu in
gallons (US)	.8327	gals (British)
gollans (US)	3.785	liters
gallons per minute	.002228	cu ft per sec
groms	.001	kg
grams	1000	mg
grams	.03527	oz
groms	.002205	lbs
hundredweight	112	lbs
inches	2.540	cm
inches	.08333	ft
inches	1000	mils
kilagroms	1000	gms
kilometers	.6214	mil
kilometers	.5396	mil (nauticol)
knots	1.152	mil per hr
knots	1	mph (nauticol)
kilowotts	1.341	hp
links (surveyors)	7.92	in
liters	1000	cu cm
liters	61.02	cu in
liters	.2200	gals (British)
liters	.2642	gals (US)
liters	1.057	qts (liquid)
meters	100	cm
meters	3.281	ft
meters	39.37	in
meters	1.094	yds
miles	5280	ft
miles	63,360	in
miles	1.609	kms
miles	.8684	mil (nautical)
miles	1760	yds
miles (nouticol)	6080	ft
miles (nauticol)	1.1516	mil
miles per hour	88	ft per min
miles per hour	.8684	knats
mils	.001	in

Table 109. Continued

Multiply	By	To obtain
ounces	.0625	lbs
pounds	7000	groins
pounds	453.6	gms
pounds	.4536	kgs
pounds	16	oz
pounds of water	.01603	cu ft
pounds of water	.1198	gals (US)
pounds per square inch	2.307	ft of water
radians	57.30	degrees
rods	16.5	ft
square centimeters	.1550	sq in
square feet	929	sq cm
square feet	144	sq in
square inches	6.452	sq cm
square inches	.006944	sq ft
square meters	10.76	sq ft
square meters	1.196	sq yds
square miles	640	acres
square miles	2.590	sq kms
square yards	.0002066	acres
square yards	9	sq ft
square yards	1296	sq in
square yards	.8361	sq meters
temp (°C) + 17.8	1.8	temp (°F)
temp (°F) − 32	.5556	temp (°C)
tons (long)	1016	kgs
tons (long)	2240	lbs
tons (ship)	40	cu ft
tons (short)	907.2	kgs
tons (short)	2000	lbs
yards	3	ft
yards	36	in
yards	.9144	meters

Table 110. Conversion Factors Linear Measure

Unit	Nautical miles	Statute miles	Kilometers	Cable lengths	Fathams	Meters	Yards	Feet	Inches	Centimeters
1 nautical mile–		1.1516	1.8532	8.445	1,013.4	1,853.2	2,026.8	6,080.27	72,963	185,325
1 statute mile–	0.8684		1.6093	7.333	880	1,609.3	1,760	5,280	63,360	160,933
1 kilometer–	0.5396	0.6214		4.557	546.8	1,000.0	1,093.6	3,281	39,370	100,000
1 cable length–	0.1184	0.1364	0.2195		120	219.5	240	720	8,640	21,945
1 fatham–						1.829	2	6	72	182.88
1 meter–					0.5468		1.0936	3.281	39.37	100
1 yard–					0.5000	0.9144		3	36	91.44
1 foot–					0.1667	0.3048	0.3333		12	30.48
1 inch–								0.0833		2.540
1 centimeter–								0.0318	0.3937	

Table 111. Time Distonce Conversion

Miles per hour	Knots	Feet per second	Kilometers per hour	Meters per second
1	0.8684	1.4667	1.6093	0.447
2	1.74	2.94	3.23	0.897
3	2.59	4.41	4.83	1.34
4	3.46	5.90	6.45	1.78
5	4.34	7.33	8.05	2.23
6	5.20	8.80	9.65	2.68
7	6.07	10.30	11.30	3.13
8	6.95	11.80	12.90	3.58
9	7.81	13.22	14.50	4.03
10	8.68	14.67	16.09	4.47
11	9.55	16.20	17.70	4.92
12	10.40	17.62	19.30	5.37
13	11.23	19.10	20.90	5.82
14	12.10	20.60	22.60	6.27
15	13.00	22.10	24.20	6.71
16	13.90	23.50	25.80	7.16
17	14.75	25.00	27.40	7.63
18	15.60	26.40	28.90	8.05
19	16.45	28.00	30.60	8.50
20	17.40	29.30	32.20	8.95
21	18.20	30.90	33.80	9.39
22	19.10	32.30	35.40	9.85
23	20.00	33.80	37.10	10.30
24	20.80	35.30	38.60	10.75
25	21.70	36.70	40.30	11.15
26	22.50	38.20	41.90	11.60
27	23.40	39.70	43.50	12.10
28	24.30	41.20	45.10	12.50
29	25.20	42.60	46.70	13.00
30	26.00	44.20	48.30	13.40
31	26.90	45.60	50.00	13.90
32	27.80	47.00	51.50	14.30
33	28.60	48.50	53.00	14.73
34	29.50	50.00	54.55	15.20
35	30.40	51.50	56.50	15.65
36	31.20	53.00	58.00	16.10
37	32.00	54.50	59.70	16.50
38	32.90	56.00	61.40	17.00

Table 111. Continued

Miles per hour	Knots	Feet per second	Kilometers per hour	Meters per second
39	33.80	57.50	62.80	17.40
40	34.60	58.80	64.50	17.83
41	35.60	60.50	66.00	18.38
42	36.40	61.90	67.70	18.80
43	37.30	63.40	69.20	19.20
44	38.20	64.80	71.00	19.70
45	38.90	66.50	72.50	20.20
46	40.00	67.50	74.00	20.60
47	40.70	69.10	75.90	21.00
48	41.50	70.50	77.50	21.40
49	42.40	72.00	79.00	21.80
50	43.50	73.80	80.50	22.30
51	44.10	74.90	82.00	22.80
52	45.10	76.50	83.60	23.20
53	46.00	78.00	85.70	23.70
54	46.70	79.50	87.00	24.20
55	47.50	80.90	88.70	24.60
56	48.50	82.20	90.00	25.00
57	49.50	83.90	91.90	25.50
58	50.10	85.00	93.40	25.90
59	51.00	86.80	95.00	26.40
60	52.00	88.10	96.70	26.80
61	53.00	89.60	98.00	27.20
62	53.70	91.10	99.80	27.70
63	54.60	92.90	101.70	28.20
64	55.60	94.20	103.00	28.60
65	56.20	95.30	104.50	29.10
66	57.20	97.00	106.00	29.50
67	58.00	98.20	108.00	30.00
68	58.90	100.00	109.50	30.40
69	59.80	101.80	111.00	30.80
70	60.70	103.00	113.00	31.30
71	61.60	104.00	114.00	31.70
72	62.50	106.00	116.00	32.20
73	63.30	107.30	117.30	32.60
74	64.20	109.00	119.00	33.10
75	65.00	110.00	121.00	33.60
100	87.00	147.60	161.00	44.60

d. KMPH and MPH. See figure 208 for a graph showing this conversion.

e. Time-Length of Vehicle Columns. See figure 209 for graph.

f. Weight and Measure Conversions from U.S. to Metric Terms. See figure 210 for charts.

g. Degrees to Mils. See table 112 for this conversion.

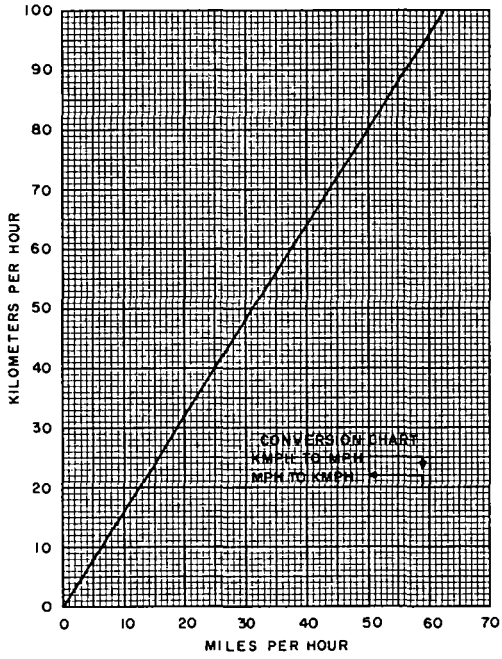


Figure 208. Conversion chart for KMPH and MPH.

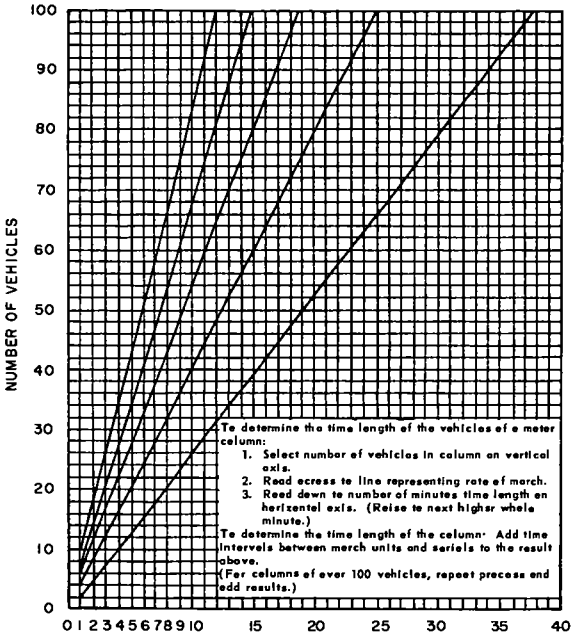

NUMBER OF VEHICLES
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10
15
20
25
30
35
40
To determine the time length of the vehicles of a motor column:
1. Select number of vehicles in column on vertical axis.
2. Read across to line representing rate of march.
3. Read down to number of minutes time length on horizontal axis. (Raise to next higher whole minute.)
To determine the time length of the column: Add time intervals between march units and serials to the result above.
(For columns of over 100 vehicles, repeat process and add results.)

Figure 209. Time length of vehicle column.

134. MARCH FACTORS

See tables 113 and 114 for information on march formulas and factors, and rates and lengths of marches, respectively.

135. LIGHT STREAM-CROSSING EQUIPMENT DATA

See table 115 for information. For more detailed information, see paragraphs 51 and 52.

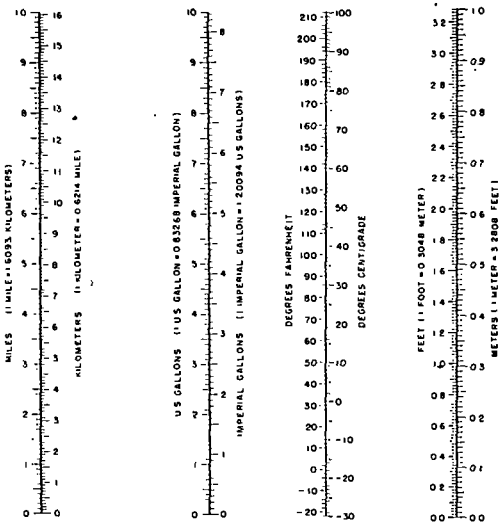

MILES (1 MILE = 1.6093 KILOMETERS)
KILOMETERS (1 KILOMETER = 0.6214 MILE)
US GALLONS (1 US GALLON = 0.83268 IMPERIAL GALLON)
IMPERIAL GALLONS (1 IMPERIAL GALLON = 1.20094 US GALLONS)
DEGREES FAHRENHEIT
DEGREES CENTIGRADE
FEET (1 FOOT = 0.3048 METER)
METERS (1 METER = 3.2808 FEET)

Figure 210. Weight and measure conversion for U. S. and metric data.

Table 112. Conversion Factors of Degrees to Mils

$360° = 6{,}400$ mils

$1° = \frac{6{,}400}{360} = 17.8$ mils (or 18 approx)

$1 \text{ mil} = \frac{360}{6{,}400} = .056°$

1 mil = 0.056° approximately
= 3 minutes 22.2 seconds

Mils = 17.8 x degrees

Table 113. March Formulas and Factors

Metric Conversion Factors

Kilometers (KM)-Miles (mi)

To convert kilometers to miles: Multiply the number of kilometers by the factor .62.

Mi = Nr of Km × .62

To convert miles to kilometers: Multiply the number of miles by the factor 1.6.

M = Nr of mi × .6.

Meters(M)-Yords(yds)

To convert meters to yords: Multiply the number of meters by the factor 1.1.

Yds = Nr of M × 1.1.

To convert yords to meters: Multiply the number of yords by the factor .91.

M = Nr of yds × .91.

For Time Distonce (TD):

Divide the distonce (kilometers) by the rote of morch (kilometers per hour).

$$TD\ (hours) = \frac{D\ (Kilometers)}{R\ (Kilometers\ per\ hour)}$$

To convert fractionol ports of on hour to minutes, multiply the fractionol port by 60.

For Time Length (TL) of Foot Column:

Multiply road space (RS) of the column by factor for rote of morch.

TL (minutes) = (RS × factor)

Select factor from toble below

Rate (kmph)	Factor
4.0	.0150
3.2	.0187
2.4	.0250
1.6	.0375

For Rood Spoce (RS) of Foot Troops:

Multiply number of men by factor for formotion ond odd the totol distonce of the intervals between units.

RS (meters) = (Nr of men × factor) + distonces

Select factor from toble below

Formation	2 M/Mon	5 M/Mon
Single File	2.4	5.4
Column of Two's	1.2	2.7

For Time Length (TL) of Motors (Open Column):

Multiply number of vehicles by factor for formotion ond rote of march ond add time intervols (TI) between units.

TL (minutes)= (Nr of vehicles × factor) + TI's

Select factor from table below

Rate (kmph)	M/Veh	Factor
16	100	.3750
24	100	.2500
32	100	.1875
40	100	1500

For Time Length (TL) of Motors (Close Column)

Multiply number of vehicles by .12 and odd the time intervols (TI) between units.

TL (minutes) = (Nr of vehicles × .12) + TI's

For Completion Time (CT):

Add TL of column, TD from IP to RP, ond ony scheduled halts other thon normol breaks, to the IP time.

CT = IP time + TL + TD + Scheduled Holts

Exemple:

Hr	Min	
07	45	IP time (clock time) time)
01	12	TL of column (1 hr 12 min)
05	55	TD (IP to RP, 5 hrs 55 min)
01	00	Meol halt (one hour)
CT = 14	112 or 1552	

The move will be completed at 1552 hours.

For Rood Spoce (RS) of Motors:

Multiply the TL (minutes) by the rate in kilometers per hour ond divide by 60.

$$RS\ (kilometers) = \frac{TL\ (min) \times R\ (Kilometers\ per\ hour)}{60\ (minutes/hour)}$$

Table 114. Rates and Length of Marches [1]

Unit	Average Rates of March (KMPH) [2]				Days March Kilometers
	On Roads		Cross-country		
	Day	Night	Day	Night	
Foot troops	4	3.2	2.4	1.6	20-32
Trucks, general	40	40 (lights) 16 (blackout)	12	8	280
Tracked vehicles	24	24 (lights) 16 (blackout)	16	8	240
Truck-drawn artillery	40	40 (lights) 16 (blackaut)	12	8	280
Tractar-drawn artillery	32	32 (lights) 16 (blackaut)	16	8	240

1/ This table is far general planning and camparisan purpases. All rates given are variable in accordance with the mavement canditians as determined by recannaissance.

2/ These rates include narmal periadic rest halts.

Table 115. Continued

Item	Use	Description	Capacity	Remarks
Assoults Boat Bridges*	Cross high-priority light vehicles.	Continuous plywood treadway w/double assault boat pontons on 10 ft. centers.	Class 8 in currents up to 3.2 KMPH	Requires constant maintenance and repair. Fabricated from raft sets, capacity is reduced to Class 2 in maximum safe current velocity of 8.8 KMPH.
Light Tactical Raft (Alum)	Ferry high-priority vehicles.	4 alum pontons and solid alum deck 33 foot loading area.	Class 16 load in current velocity of 8 KMPH. Class 8 load in current velocity of 9.6 KMPH.	This raft will replace the Infantry Support Raft as organic equip to Inf. Div Engr Bn. Two rafts organic to Div. Engr. Bn.
Aluminum Footbridge	Cross troops w/tactical unity.	Successive boys of one pontan and one treadway	75 men/min. in currents up to 8.6 KMPH during daylight. 40 men/min in same current velocity at night w/quarter moon illumination. 25 men/min. in same current velocity in blackout.	Bridge considered safe in current speeds up to 12 KMHP with caution crossing (men one bay apart) 472 feet of bridge per Float Bridge Company transported on two 2½ ton trucks w/trailers.
Boat Landing Pneu	Assault crossing	Nylon, pneu 12 air empty wt 210 lbs.	12 fully equipped infantrymen crew 3 engr.	18 in Div. Engr Bn can be paddled or power supplied by 25 BHP motor. 13 KMPH in currents of 7 KMPH

*Limited Standard.

Table 115. Engineer Light Stream-Crossing Equipment Data.

Item	Use	Description	Capacity	Remarks
Three-man Reconnaissance Boat	Reconnaissance	Canvas w/5 Compartments Issued w/towline and 3 paddles. Total wgt 30 pounds	Three men in current speeds up to 4 KMPH.	Boat is breath-inflated or hand pumped Easily carried by one man when deflated and packed in case Div. Engr Bn -- 18 boats.
M3 Assault Boat	Initial Crossing	Plastic, hand paddled Weight 270 pounds	12 Infantrymen w/full equipment or equivalent in current speeds up to 4 KMPH.	Normal crew, three engineers. Maximum capacity w/no current is 3300 pounds. Can be propelled by 1-25 HP outboard motor at speed of 12.8 KMPH w/o a load reduction
Double Assault Panton*	Speed Crossing. Infantry Support Raft Infantry Light Tactical Bridge.	Two M2 Assault boats joined stern-to-stern w/steel pins	22 Infantry w/full equipment or equivalent in current speeds up to 7.6 KMPH.	Normal crew, two engineers. Power supplied by 1-25 HP outboard motor. Maximum speed 9.5 to 12 8 KMPH Can be paddled in currents up to 7 6 KMPH with a full load and in currents up to 6.1 MPH with a load of 15 Infantrymen, plus engr crew.
Storm Boat*	Speed Crossing.	Plywood, Double-bottomed Weight 440 pounds w/o motor.	7 Infantry w/full equipment or equivalent.	Normal crew, two engineers. Power supplied by 2-25 HP motors. Maximum speed 32 to 40 KMPH. Capable of crash-landing at full speed. Engr CL IV Supply.
M3 Assault Boat Employed as Storm Boat	Speed Crossing.	Plastic Weight: 290 pounds	5 Riflemen w/full equipment and 1-man crew	Maximum speed 32 KMPH. Capable of crash-landing at full speed. Can be used in currents up to 12 KMPH. Power supplied by 1-25 HP Motor.
Infantry Support Raft*	Ferry high-priority light vehicles.	3 double assault boat pantons 6 plywood treadways 5 double assault boat pontons and 8 treadways.	Class 8 Load Class 13 Load	Capacities apply for current speeds up to 3.2 KMPH By use of cables, same capacities may be crossed up to 7.6 KMPH. 3-panton raft is constructed by trained plat in 10 minutes, 5-panton raft in 15 minutes.

136. CAMOUFLAGE

The proper choice of position and camouflage discipline will, in most cases, provide adequate concealment. When this concealment is inadequate, we must then resort to camouflage construction and its three methods, hiding, blending, and deceiving.

a. Camouflage Principles.

(1) Siting. Siting, or choice of position, is nothing more than choosing the most advantageous position to conceal the object while still being able to accomplish the mission.

(2) Discipline. Camouflage discipline is simply the avoidance of any activity which changes the original appearance of an area.

(3) Construction. Camouflage construction is done to improve concealment when choice of position and discipline are inadequate.

b. Camouflage Materials.

(1) Natural material. Natural materials generally provide the best concealment, and are always available. Natural materials include live vegetation, cut vegetation, debris, and the inert surface of the earth.

(2) Artificial material. Artificial materials are any manufactured items that can be used for camouflage purposes. They are used only when the use of natural materials is impossible or impracticable. They include paints, supporting materials, garnishing materials, structural materials, screening materials, adhesives, and texturing materials. Colors used must be in harmony with the predominant colors of the area where they are used.

c. Individual Camouflage.

(1) Choice of background is a controlling factor for proper individual concealment. The soldier should make effective use of terrain, adapt his clothing to the terrain, and carefully select his route during movement to benefit from the best concealment. Camouflage activities must be effective against enemy observers both on the ground and in the air. Skin, clothing, and equipment must be toned down to blend with the background. Distort the distinctive shape whenever possible. Achieve such concealment by strict adherence to the following practices.

(a) Helmets. Break up the shape by the use of leaves or twigs secured with a rubber band, or by making a cover of burlap, distorted with burlap garlands, and paint appropriate colors.

(b) Skin. Tone down all visible skin areas with issue face paint. This is one exception to the use of natural materials. Mud is frequently harmful to the skin and is too easily removed. Leaves and other stains do not

remove the shine. Use light green and loam face paint for white troops in all but arctic climates. Use white and loam for all troops in arctic climate. Lighten the shadow areas of the face and darken the shine areas. If issued type face paint is unavailable, burnt cork is the best and safest substitute.

(c) Clothing. The Army issues no special camouflage clothing except a snow suit for use in the arctic. In order to provide additional concealment, the clothing may be toned down to blend with the background by use of camouflage paints. Choose two or three appropriate colors and apply in large, bold patterns to distort shape and blend with surrounding terrain.

(d) Equipment. Tone down canvas equipment to avoid contrast with clothing or surroundings. Remove shine from metal objects with mud or face paint. Distort the shape of a weapon with vegetation or burlap, but be sure this does not interfere with the operation of the weapon. Shiny objects, such as mess gear and canteens, must be covered and kept out of direct sunshine at all times.

(2) Silhouette and shadow. Avoid exposing a silhouette and creation of shadows. This applies at night as well as during daylight hours.

(3) Selection of routes. Choose routes carefully during daylight or at night. Cross open areas quickly, and travel slowly along natural terrain features where concealment is effective.

d. **Camouflage of Emplacements.**

(1) Proper site selection is the most important consideration because it makes the job of camouflage simpler. Realizing that the enemy has aerial observation, avoid regular geometric layouts of the positions of vehicles, weapons, and materials. Use natural camouflage material as much as practicable supplemented by artificial materials. The artificial materials include nets and covers (burlap, corrugated iron, and wood).

(2) Conceal vehicle tracks so that the terrain remains natural. Use overhead screen wire where needed.

(3) Eliminate shine on equipment and camouflage.

(4) Use shadows to conceal vehicles and equipment or park vehicles under natural cover. If this is insufficient, a garnished net should be used. A bivouac should be dispersed or camouflaged to fit the terrain.

(5) In urban areas, use shadow cast by buildings to help conceal material.

(6) In desert terrain, tents may be camouflaged by digging down so that the top of the tent is at ground level, and camafloging.

(7) Supplies may be either hidden under natural concealment, concealed by nets, or stocked along natural terrain lines.

(8) Rules of thumb for determining net size in the field are as follows:

(a) To get net of correct width, add the width of the equipment to twice the height of the equipment, and then add 5 feet.

(b) Compute length of net in same way.

(c) If net size thus computed falls between two standard sizes, use larger net size. In some cases, two standard nets should be joined to obtain proper size net.

e. Garnishing

(1) Garnishing density. All nets should be garnished to a predetermined degree of density. Drape nets should be garnished 100% in the center portion of the net, thinning out to 65% toward the outer edges. This will result in a coverage of about 85% of the entire net area. Flat-top nets should be garnished 100% in the center portion of the net, thinning out to 25% toward the outer edges. This will result in a coverage of about 65% of the entire net area. Begin the thin-out at about one-half the radius of the net. This must not be an abrupt change in percentages, but rather a gradual thinning-out so as to achieve a smooth transition to the desired density at the outer portion of the net.

(2) Garnishing patterns. To provide for blending into a variety of seasonal and geographic terrain characteristics, pregarnished twine nets are issued in two blends -- the all seasonal and the desert. The color blend of a net is achieved by proportionately varying the garlands of the various colors required for a particular blend, and placing the garlands in the net as an overall mixture of colors. Long straight runs, large areas, blocks of one color, or regularity of pattern in a net should be avoided. Generally, the garlands are inserted into the net in such a manner that each garland will describe one of the following letters: L, U, S, C, or I (fig. 211). This should result in an amalgamation of letter patterns forming the desired degree of density and color blend.

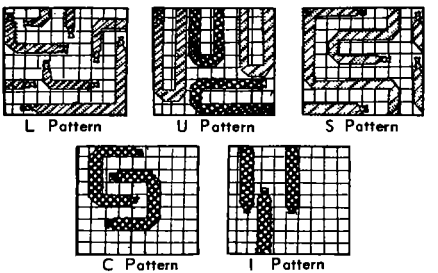


Figure 211. Garnishing

APPENDIX I
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AR 105-30	Joint Use of ICAO Phonetic Alphabet
AR 105-31	Message Preporotion
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DA Pom 310-1	Militory Publicotions: Index of Administrotive Publicotions
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DA Pom 310-5	Military Publications: Index of Grophic Training Aids and Devices
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SM 9-4-4940-A 09	Demolition Equipment Set, Explosive Initiating, Electric ond Nonelectric
SM 9-4-4940-A 10	Demolition Equipment Set, Explosive Initiating, Nonelectric

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FM 5-6	Operations of Engineer Troop Units
FM 5-15	Field Fortifications
FM 5-20	Camouflage Basic Principles and Field Camouflage, with change 1
FM 5-21	Camouflage of Fixed Installations
FM 5-22	Camouflage Materials, with change 1
FM 5-23	Field Decoy Installations, with change 1
FM 5-25	Explosives and Demolitions, with change 1
(S)FM 5-26	Employment of Atomic Demolition Munitions (ADM) (U)
FM 5-30	Engineer Intelligence
FM 5-31	Use and Installation of Booby Traps, with changes 1 and 2
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FM 5-36	Route Reconnaissance and Classification
FM 8-35	Transportation of Sick and Wounded, with change 1
FM 8-50	Bandaging and Splinting
FM 10-13	Quartermaster Reference Data, with change 1
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FM 21-5	Military Training
FM 21-6	Techniques of Military Instruction
FM 21-10	Military Sanitation
FM 21-11	First Aid for Soldiers
FM 21-26	Map Reading
FM 21-30	Military Symbols
FM 21-31	Topographic Symbols
FM 21-40	Small Unit Procedures in Nuclear, Biological, and Chemical Warfare, with change 1
FM 21-60	Visual Signals, with changes 1-3
FM 21-76	Survival, with change 1
FM 30-5	Combat Intelligence
FM 31-10	Barrier and Denial Operations, with changes 1 and 2
FM 31-60	River Crossing Operations
FM 31-70	Basic Cold Weather Manual
FM 31-71	Northern Operations
FM 55-15	Transportation Corps Reference Data
FM 101-10	Staff Officers' Field Manual: Organization Technical and Logistical Data, Part I, with change 1

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TM 5-200	Camouflage Nets and Net Sets
TM 5-210	Floating Bridges and Rafts
TM 5-220	Passage of Obstacles Other Than Minefields, with change 1
TM 5-223	Foreign Mine Warfare Equipment
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TM 5-270	Cableways and Tramways
TM 5-271	Light Stream Crossing Equipment
TM 5-277	Panel Bridge Bailey Type, M2
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Steel	104	316
Timber	103	316
Wounds, first aid for	81a	250
Yield, concrete	56d	199

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BY ORDER OF THE SECRETARY OF THE ARMY:

G. H. DECKER,
General, United States Army,
Chief of Staff.

Official:

J. C. LAMBERT,
Major General, United States Army,
The Adjutant General.

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For explanation of abbreviations used see, AR 320–50.

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